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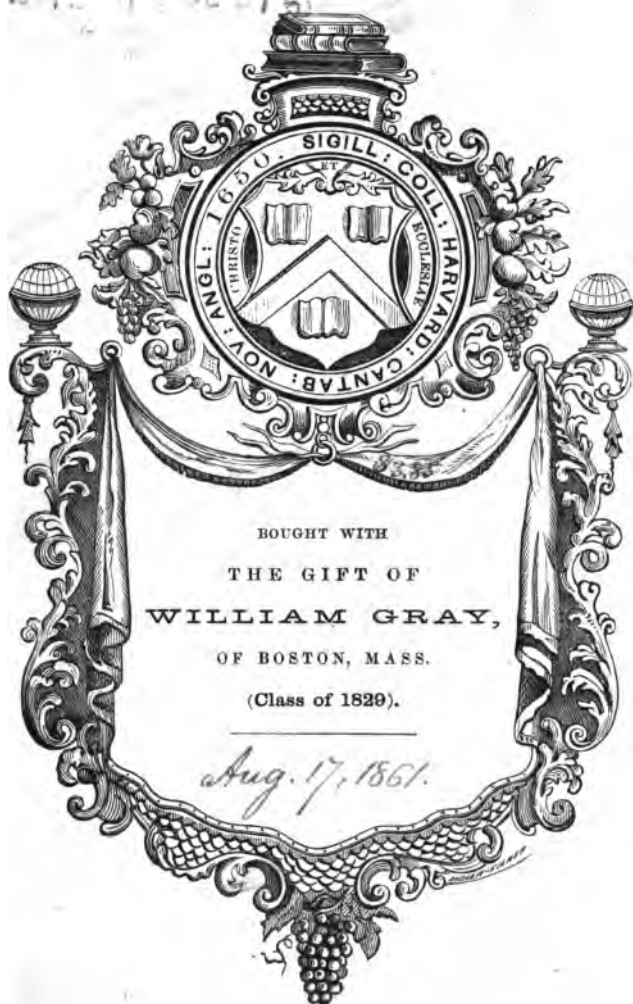
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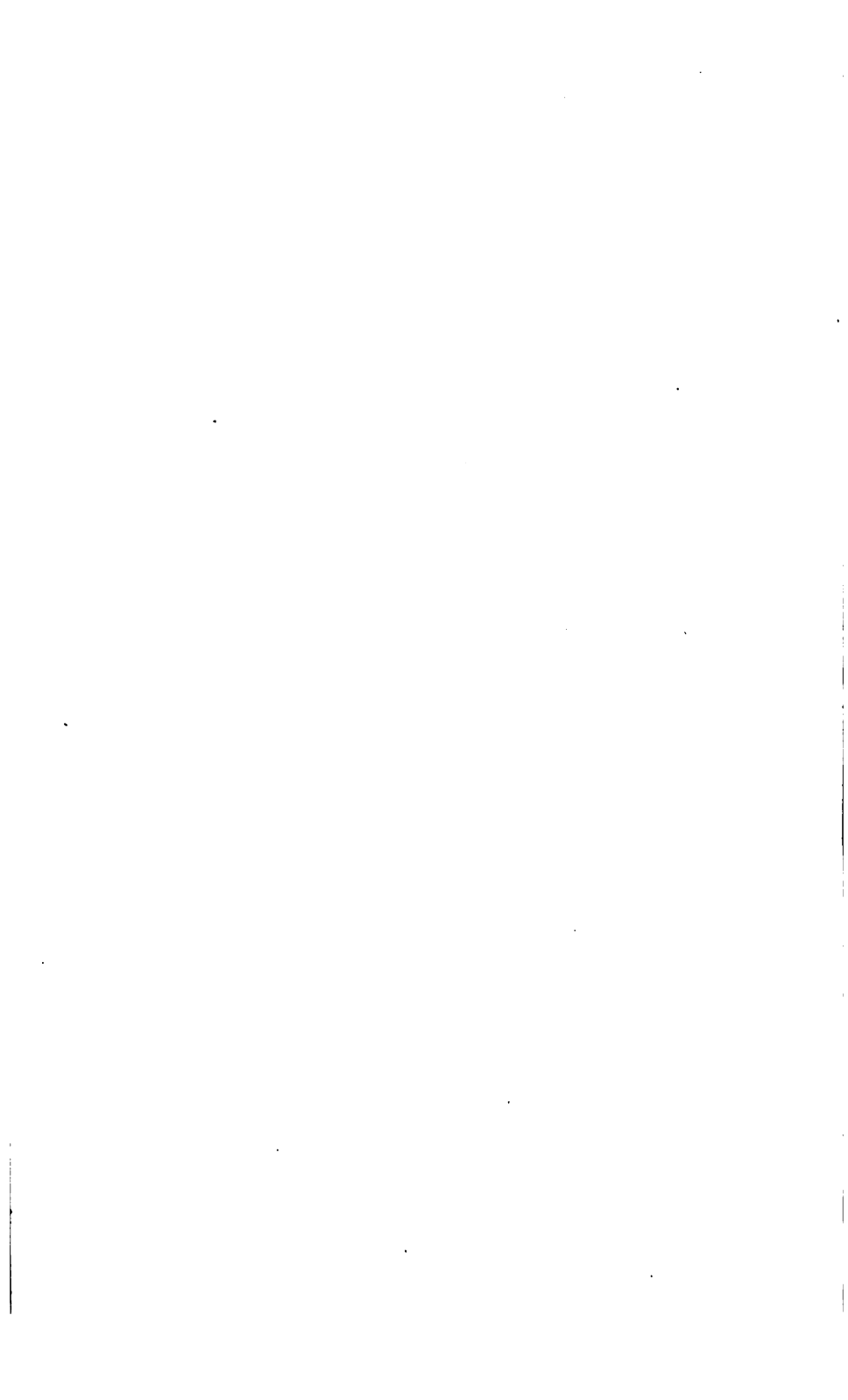
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CHEMISTRY

OF

CALICO PRINTING, DYEING,

AND

BLEACHING,

INCLUDING

SILKEN, WOOLLEN, AND MIXED GOODS,

PRACTICAL AND THEORETICAL:

WITH COPIOUS REFERENCES TO ORIGINAL SOURCES OF INFORMATION, AND
ABRIDGED SPECIFICATIONS OF THE PATENTS CONNECTED WITH
THESE SUBJECTS FOR THE YEARS 1858 AND 1859.

BY

CHARLES O'NEILL.

C MANCHESTER:

DUNNILL, PALMER, AND CO., 1, 3, & 5, BOND STREET.

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P R E F A C E .

IN twenty or thirty years hence, a Treatise on the Chemistry of Calico Printing, Dyeing, and Bleaching will be a very different work from this. Such a title to a book now can only intimate that an attempt has been made to connect the various phenomena occurring in these arts with the already discovered laws of chemical science, and this only with regard to very subordinate operations. Such a title to a book *then* may be expected to indicate an exposition of the laws governing the combinations of fibrous matters, to point out the causes of colour and of its disappearance, and to show what is the chemical difference between a white and a coloured fibre.

At this moment, there is no single experiment on record which will enable the reader to judge whether the colouring of a fibre, by dyeing, is a chemical phenomenon, properly so called, or not; nor a quantitative determination of how much alumina, iron, or tin, may combine or be attached to cotton, wool, or silk; nor how much colouring matter may combine with those metals; nor whether there are any definite compounds of these matters or not.

The grossly mechanical expressions used by Hellot, more than a century ago, to express the nature of dyeing, are echoed by one of the most intelligent printers of our day; and, a few

weeks ago, in the French Academy, M. Chevreul, one of the foremost chemists in the world, finds need to invent a new term to express his idea of dyeing. From Hellot's "gaping pores" to Chevreul's "capillary affinity" where is the progress made?

There is no chemical theory of dyeing worthy of the name.

This work simply sets forth the properties of the chemical materials used in printing, dyeing, and bleaching; describes their actions upon one another, and, as far as may be, explains the conditions necessary to success in every department of these arts. The limits of the book have precluded minute details frequently found in kindred works, but nothing has been knowingly omitted which seemed necessary. The author's practical acquaintance with most branches of these arts, derived from several years' experience in an important establishment, has enabled him to discuss some points of practical detail in a manner which might seem too confident without this explanation. His statements are the result of actual working, and, though sometimes at variance with those of accepted authorities, may, nevertheless, deserve an equal credit.

For those who may wish to inquire into minuter details a copious list of references to original papers is given; a list of patents upon subjects connected with dyeing and printing, and the more recent standard works upon these subjects.

MANCHESTER,

SEPTEMBER, 1860.

INTRODUCTION.

EVERY operation in dyeing (under which term may be understood the allied arts of bleaching and printing) may be considered as directly chemical, and all mechanical appliances as so many apparatuses intended to facilitate or regulate the chemical actions taking place between the fibre, the mordant, and the colouring matter. As these actions vary in kind or degree for every colour produced, it may be readily granted that there is no art so intimately connected with chemistry, or depending so much upon chemical laws and phenomena, as dyeing. And yet it is plain that many successful dyers and colorists know nothing of chemical science, and even affect to despise it; but, though they may not admit or feel it, their success is entirely owing to a certain aptitude in perceiving the laws which govern the matters they work with, and adapting themselves to these laws,—and this is just what chemistry would teach. The highest science can do no more than understand nature, and the highest art is that which follows its laws with the greatest exactness. The difference between simple practical ability, as opposed to scientific knowledge, is merely one of degree, not of kind. The one is special, the other general. The ability of the merely practical man, however expert he may be in a few operations, is no more than that of a juggler, whom long practice and many a mishap has taught to catch a ball or balance a feather with unfailing certainty. Science shows that the same law of nature which governs the fall of the ball, or supports upright the trembling feather, extends through the whole universe, and that a study of it enables eclipses and transits to be predicted, and many benefits to be conferred upon mankind. If catching balls and balancing

feathers were everything, then the practice might be justified in condemning the theory ; but when the theory leads to much higher and more noble results, it must be respected, even if it be not comprehended. A man may probably become a good dyer and colorist without chemistry, but he will be a much better one with a knowledge of that science.

The want of a better knowledge of chemistry in print and dye works is a constant source of loss and trouble to the employers. They are subject to losses from impurity and deficiency of strength in their drugs, from waste of valuable materials used in unnecessary quantity, from accidents which might have been avoided ; and, in many cases, are helpless in the hands of servants of little skill and integrity, and, by a guilty collusion, become the easy victims of dishonest tradesmen. With a more accurate and extended knowledge of chemistry, many causes of failure, now only guessed at, could be traced with certainty to their origin, and the recurrence of the accidents guarded against. At present, when goods are spoiled and the cause is not clearly visible, what difficulty in tracing them to the exact place where they received the injury. Each person in charge seeks to exonerate himself by laying the blame on some other department, or upon the materials supplied, and very frequently inquiry is baffled, or injustice done. A knowledge of chemistry would often show the cause of the bad result, and relieve both servants and manufacturers from injurious suspicion. In calico printing and dyeing very small causes produce serious effects, and it is difficult for the highest intelligence to discover the particular stage at which a given result has happened, and, if there, why it has happened, unless that intelligence be backed with a competent chemical knowledge. Instead of pointing out the cause of the accident, and how it is to be avoided in future, it is customary simply to direct the man in charge to look to it, or take the consequences ; and, though the knowledge of minutiae, and the acuteness of a good foreman, stimulated by the fear of the loss of his place, generally triumph, there are many instances where such persons have suffered from circumstances beyond their control : the bleacher blamed, when the fault lay in the ash or rosin supplied to him ; a colour-mixer blamed, though the preparation of the cloth was in fault ; the dyer blamed,

owing to a change in the water, and so on ; one man suffering for another's ignorance or carelessness.

The art of colouring cloth is so entirely a sequence of chemical processes, that no one who is not something of a chemist can hope to follow the various steps with clearness or certainty. The extension of chemical knowledge would not only tend to correct errors and give more certainty to existing methods, but it would enable new methods to be contrived, and new colours to be produced, to a much greater extent than has hitherto been the case in this country. The majority of the recent improvements in dyeing have not originated in England ; they are of continental, and chiefly of French origin. We may mention garancine and garanceux, the applications of albumen and caseine, the introduction of murexide, picric acid, and the modified archil colours ; and, though Mr. Perkins has the credit of reducing the aniline colours to practical manufacture and application, it was a French chemist who first indicated the possibility of obtaining colours from such a source, and it is to France we owe that red modification of the aniline colour, which is the latest chemical product, and yields the most beautiful shades upon silk. This unfavourable position of England with regard to France is entirely owing to the lesser amount of chemical skill brought to bear upon the art. In France the study of chemistry has been encouraged by the government for a long period, and its applications to dyeing have been specially promoted and fostered by the appointment of some chemist to a recognised post, in connection with the government dyeing establishment of the Gobelins. The names of Dufay, Hellot, Macquer, Berthollet, and Chevreul have respectively shed lustre upon the appointment, and their talents contributed to the perfection of the art. It may be safely said, that for one person of an adequate chemical education connected with dyeing or printing in England, there are ten such in France ; hence their high position in these arts with regard to the finer styles and qualities. It is said, as a set-off to this, that we are unequalled in the lower class of goods for excellence and cheapness ; but there is ground for doubting a continued superiority even here, as those who have studied the productions of Rouen and Roubaix are ready to testify. Indeed, chemical skill were of little use if it could not economise as

well as invent, and it will be unsafe to rest upon any such supposed advantage which, if it have any existence, is only temporary, and due to our improved mechanical appliances.

Though the balance of discovery has been against us lately, there is nothing discouraging in it; there are sufficient examples of ability and success among British dyers and printers to convince anyone that if the chemically educated portion were more numerous, they would be as conspicuous for their chemical, as they are now for their mechanical genius, and might hold their own ground against the competition of the whole world. When, moreover, the relative populations of Great Britain and those parts of the Continent which contribute to the advance of dyeing is taken into account, the position of this country does not appear so unfavourable, for all improvements made in France, Switzerland, Belgium, Northern Italy, and a large part of Germany, are announced through France, and are thus usually attributed to the French nation, while British improvements are really from the limited population of these islands. The names of Higgins, Bancroft, Thompson, Crum, Mercer, and Schunck, may well stand in the same rank as those of Haussman, Hellot, Koechlin, Schlumberger, and Chevreul.

In fact, the intelligent dyer or printer can no longer afford to have his business conducted in ignorance of chemistry, for new colours are being introduced entirely different from the older supplies, and requiring a different kind of knowledge on the part of those using them. It is only now that the scientific chemist is beginning to show that he has ceased to be simply a pupil of the dye-house, endeavouring merely to understand and explain processes known for centuries before there was any chemical science; the chemist is now taking higher ground, presenting new tinctorial matters, the products of recondite chemical reactions, and indicating entirely new processes of treatment. Picric acid yellow, aniline purple, and murexide red, are as much artificial preparations as a watch or a steam engine, and as different in their origin from the colours of logwood or indigo as the obsidian knife of an early Mexican is from a polished steel blade. Nor is it likely that the operations of the laboratory will stop with the production of these colours; vast regions remain yet to be explored, and many a brilliant and useful pigment is

now known to exist, requiring only further working and knowledge to make it available to the trade. The skill of the applier of these colouring matters must in some sort correspond with that of the producer, and as they are, from their first commencement, products of chemical art, their nature and properties can only be understood by means of chemistry. If further inducement were necessary to encourage the study of chemistry among those who have the direction or management of establishments, attention might be drawn to the pecuniary advantages of a dazzling nature it holds out to the successful investigator, and, at the same time, to the many opportunities which are afforded to skill and perseverance of becoming successful. The number of colouring matters at our disposal is very limited, and the processes by which they are applied, in many cases, tedious and expensive. For example, there is only one fast red upon cotton, which is from madder ; and only one fast blue, which is from indigo. Can neither nature nor art add to these two substances ? Nature has indeed been well explored, as far as her spontaneous productions are concerned, and seems to answer in the negative. Chemical science and art have not yet answered, except we take the murexide purple and fuchsine pink as the first feeble attempt at what will soon be a more successful reply. Day by day the relations which exist between the various vegetable matters are being more clearly perceived, and in proportion the power of the chemist to mould them to his purposes increases. Synthesis is now as common in organic chemistry as analysis was some years ago. The solitary feats of the artificial production of Formic acid and Urea, so celebrated in their day, are now equalled every month. Nature works only by natural laws given at the first impulse of creation, and in so far as the chemist has possession of the elements and can direct the forces of nature, so long may he look forward to the readier and more economical production of natural products. As sulphuric acid was at one time made in small quantities and with difficulty from the distillation of native sulphate of iron, and is now made abundantly and cheaply from its component elements, so there is no doubt the colouring principles of many a costly dye wood will be produced in the future course of chemistry. What sources of fortune and

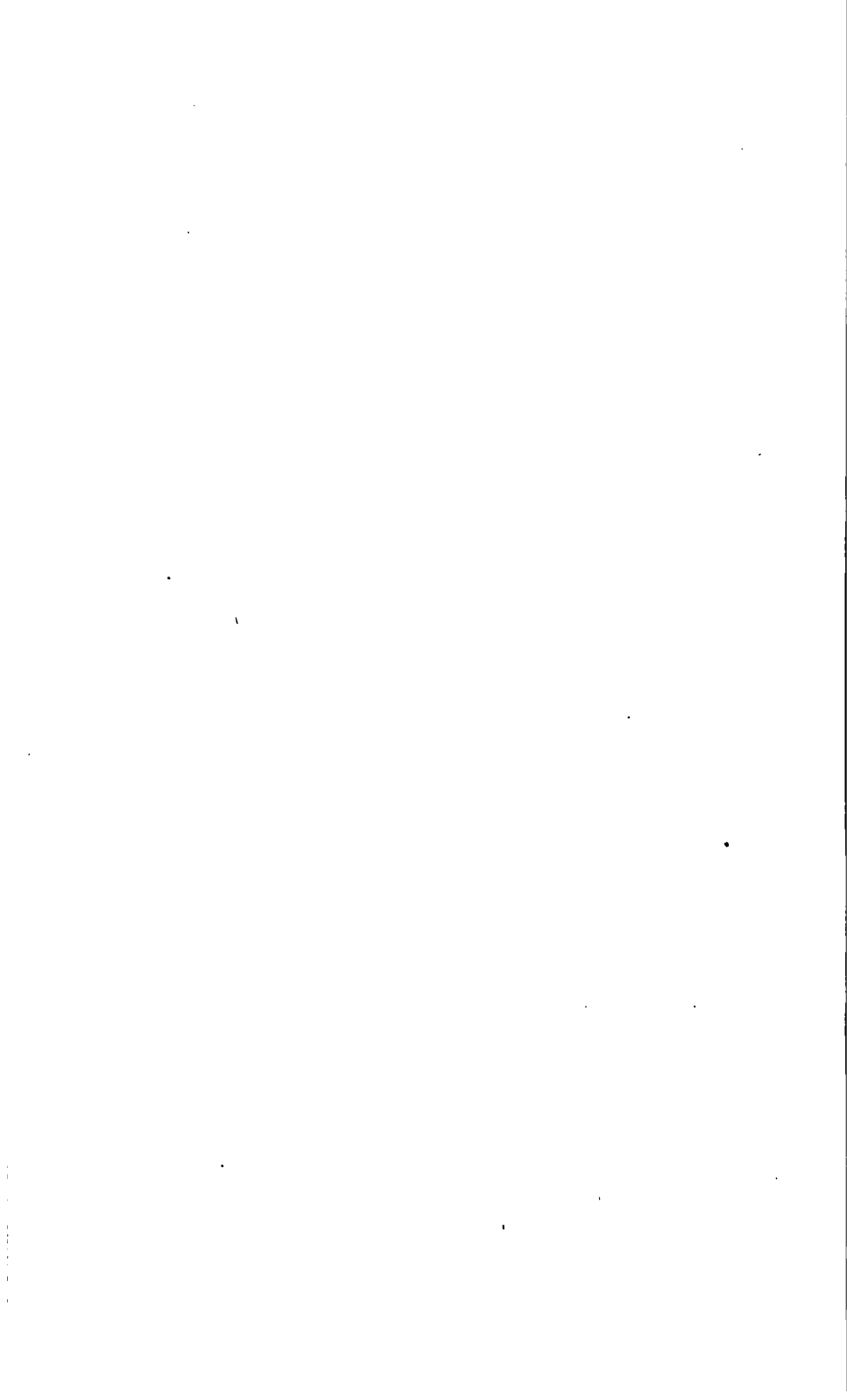
renown there are in prospective here every printer and dyer knows who has seen the avidity with which novelty is received, and who feels the vast extension of which his art is capable.

A much more extensive knowledge of chemistry than can be acquired from this volume might be applied with great advantage on every large print works or dyeing establishment. Upon a print works especially, there should be some person of chemical education, with conveniences for analysing drugs and making experiments. The occasions in which a skilful chemist can be of service in such a situation are far more numerous than would be readily admitted; and if he combined with his other duties the superintendence of such chemical manufactures as can be profitably undertaken upon a works, the economical results could not fail to be satisfactory. Gum, soap, garancine, iron, alumina, and tin mordants, extracts, etc., can be made as cheaply on the small scale as the large; and not only the manufacturer's profits, including commission, cartage, etc. saved, but, in most cases, a better and more regular product obtained. This work has no pretensions to give instructions to such a chemist, but it may enable some chemists to see what is required, and stimulate some employers to take advantage of the higher chemical education now so easily obtainable.

Many young chemists have failed to make themselves useful in practical establishments, because they have tried to apply high science without sufficient experience. We are very far from making colours by atomic weights yet. Another cause of failure is the incorrectness with which practical operations are referred to in the scientific works usually read: they mislead the student, and prejudice him against receiving more correct ideas. His education will frequently lead him to have a contempt for practical men, who, by force of practice and observation, are often better chemists than himself, though they can hardly write their names. A youth may have completed a successful chemical course at an university, under a professor of European renown, and know nothing of what is required on a print works. Besides all that he will have to learn, there will be a great deal of favourite knowledge to unlearn. He should recollect that he has entered into a sphere where chemical reactions were known and practised before science had yet

created names for them, and where many an one is now employed, inexplicable by the existing laws of science. He will find precipitates forming where there should be none, and transparent liquors where there should be precipitates. He will find insoluble matters easily dissolved by rude and unscientific menstrua, processes in use which appear incomprehensible or absurd, and proportions of salts prescribed which seem to set the scale of equivalents at open defiance. Close study and observation will soon reconcile these apparent anomalies; and though the chemist may soon lose respect for particular books and schools, he will adhere more firmly to the true principles of his science. His beautiful volumetrical methods, giving indications to the third place of decimals, will be banished for ancient plans which have no pretensions to decimals at all; and in all other things he will learn that it is folly to have one link of a chain stronger than the rest.

The acquisition of a sufficient amount of chemical knowledge to be useful on a print works takes more time than is usually allowed: a manufacturer may send his son to a laboratory for three or six months, and expect him to return a chemist, and think there is nothing in the science unless he immediately shows his knowledge. A student is more likely to do harm than good by the crude notions to be acquired in so short a time. A knowledge of an ancient or modern language is not expected to be gained in so brief a period, and yet chemistry is a science occupying much more ground than most languages; and being so much a matter of experiment and experience, can only be acquired by years of working and observation.



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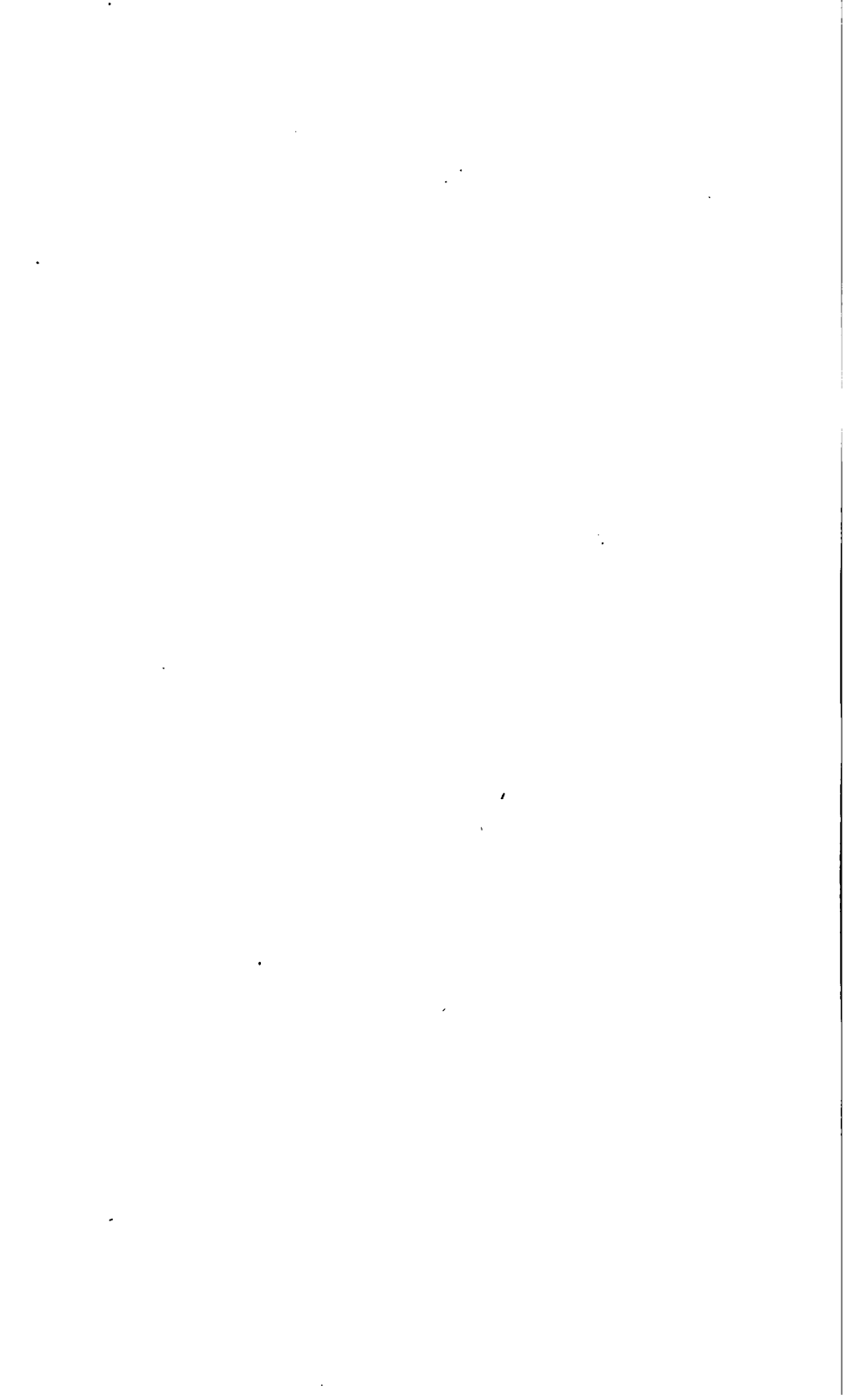
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PART FIRST.

PROPERTIES AND POWERS OF THE MATERIALS USED IN BLEACHING, DYEING, AND PRINTING.

CHAPTER I.

HEAT—LIGHT AND COLOUR—SPECIFIC GRAVITY—WEIGHTS AND
MEASURES—CHEMICAL ELEMENTS.

HEAT.

HEAT is not a substance, but only a condition of bodies supposed to be produced by the internal vibration of their particles, or a subtile fluid permeating them. The chief phenomena caused by heat are expansion, liquefaction, ebullition, and decomposition, which are referred to, as applied to particular cases, throughout the following chapters. Heat exalts all chemical affinities; many of the chemical actions observed in the arts could not take place at natural temperatures on account of the feeble attraction existing between the different bodies, or would only take place very slowly. Most dyeing operations require an elevated temperature, in order to obtain a combination of the colouring matter with the mordant. Many chemical decompositions take place near the boiling point of water, which are not observed at lower temperatures.

The steaming of colours on calico or delaine is a case of the application of heat to effect chemical combinations and decompositions, which are not effected at the temperature of their first application. The degree of heat which is employed in the operations of colour mixing and dyeing has so great an influence upon the results, that it is necessary to have some measure of temperature less uncertain than its effect upon the senses. Some dyers and colour mixers may be able to accomplish their work by ascertaining the temperature of fluids by the hand, or similar means; but those who aim at accuracy and regularity should be familiar with the thermometer or heat-glass.

The Thermometer.—The action of the thermometer in ordinary use is based upon the expansibility by heat of the mercury contained in the bulb; when the medium surrounding it is warmer than usual, the expansion of the mass of metal below forces a column of it up the narrow or capillary tube above; when the medium is colder than usual, the contraction of the bulk causes the entry of that in the tube into the bulb, and a consequent fall of the column; and as this expansion and contraction are constant for the same variations of heat, a good measure of actual temperature is obtained. On Fahrenheit's thermometer the scale runs from 32° , or the freezing point, to 212° , the boiling point, of water. The only precaution required in using the thermometer is not to plunge it too suddenly from a hot to a cold liquid—there is a risk of breaking the instrument or of interrupting the continuance of the column in the hair tube; when this latter accident occurs, it may be remedied by gently tapping the instrument, or by tying a cord securely to the upper part of the instrument and whirling it round with velocity. The scales of thermometers used on the continent differ very much from that of Fahrenheit. The one chiefly used, called the Centigrade, has the freezing point marked 0° , and the boiling point 100° ; another one, used in the northern countries of Europe, Reaumur's, has the freezing point at 0° , and the boiling point at 80° . To convert the degrees upon the scales of these thermometers into the corresponding ones upon Fahrenheit requires only simple multiplication; each degree of the Centigrade thermometer is equivalent to a degree and four-fifths of a degree of Fahrenheit's, and each degree of Reaumur's is equal to two degrees and a quarter of Fahrenheit's; by multiplying the degree of either of these thermometers by the proper numbers, and adding 32° to the product, the equivalent degree of Fahrenheit will be found. Receipts and processes frequently arriving in England from France and Germany, with the temperatures marked in degrees of one of these thermometers, a table is here given showing the correspondence between the three

instruments for a sufficient number of degrees ; the fractional parts of a degree are omitted in the Fahrenheit column :—

TABLE SHOWING THE CORRESPONDING DEGREES UPON THE CENTIGRADE, REAUMUR, AND FAHRENHEIT THERMOMETERS.

CENT.	REAU.	FAHR.	CENT.	REAU.	FAHR.
100	80	212	50	40.0	122
98	78.4	208	48	38.4	118
96	76.8	205	46	36.8	115
94	75.2	201	44	35.2	111
92	73.6	198	42	33.6	108
90	72.0	194	40	32.0	104
88	70.4	190	38	30.4	100
86	68.8	187	36	28.8	97
84	67.2	183	34	27.2	93
82	65.6	180	32	25.6	90
80	64.0	176	30	24.0	86
78	62.4	172	28	22.4	82
76	60.8	169	26	20.8	79
74	59.2	165	24	19.2	75
72	57.6	162	22	17.6	72
70	56.0	158	20	16.0	68
68	54.4	154	18	14.4	64
66	52.8	151	16	12.8	61
64	51.2	147	14	11.2	57
62	49.6	144	12	9.6	54
60	48.0	140	10	8.0	50
58	46.4	136	8	6.4	46
56	44.8	133	6	4.8	43
54	43.2	129	4	3.2	39
52	41.6	126	2	1.6	36

LIGHT AND COLOUR.

We perceive objects and colours by means of rays of light proceeding from them to the visual organs, not by any emanation from the eyes or direct power exercised by them. Light, as it proceeds from the sun, has no colour, but it contains the elements of all colour ; as a fluid which, though clear and transparent, may contain several chemical ingredients. Light can be analysed by the prism which separates it into seven colours, but only three appear to be essential, the other four being produceable by mixture. The three primary colours are red, yellow, and blue ; the secondary, green, orange, violet, and indigo. All colours may

be looked upon as produced immediately by light, and mediately by the colouring substances. That is to say, that the chemical substances—Prussian blue and vermilion—are not in themselves blue or red, but only so because they can act upon the rays of light in such a manner as to decompose them ; the first, for example, absorbing and destroying the red and yellow rays, leaving only the blue ones visible ; the vermilion, nullifying the blue and yellow rays and reflecting the red ones, and so on with all other colours. A colouring matter should not then be looked upon as the seat of colour, but as the possessor of a power of decomposing light. It is an accidental rather than an essential property ; all colours are alike in the dark ; they are not the same in daylight as in artificially coloured light ; and chemical substances may change colour, or lose colour altogether, without altering their chemical composition. Effects of colour may be produced by light in two ways ; by light being reflected from the surface which appears coloured, as is the ordinary case ; or by light being transmitted through the body which is coloured, as in stained glass or liquids. Some substances have very different colours by transmitted and reflected light. Crystals of murexide are green by reflected and red by transmitted light, and there are a number of similar cases. This is an additional proof that it is the position or physical arrangement of the particles of a body which makes its colour, and not the body itself.

Influence of Colours upon one another.—It is known that certain colours are improved by juxta-position, and others injured. Black looks better beside white than by itself, and the white is similarly improved ; the same colour placed upon different coloured grounds will not appear the same shade. For example, take a madder purple, and paint upon it, or place upon it, a perfectly black colour, the black will look green and dull ; if the black be of a purple shade, so much so as to appear a bad black upon white paper, it will, when placed on the purple, be a good and perfect black. This is not a direct effect upon the visual organs, it is a secondary one produced by the influence of the ground colour. It has been found that the eye no sooner feels one colour than it creates another, which is called the complementary colour of the first ; it is always that colour which, added to the real colour, would make it into white. The retina seems to be uneasy under the impression of a partial number of the rays of white light, to be put into an abnormal condition, which it seeks to neutralise by adding the deficient rays from some objects not so active in influencing it ; or, viewing it as a passive agent, it becomes less sensitive to those coloured rays which it has been enduring, and, turning to other

objects, it is not impressed by rays of the same colour which may be reflected, and attributes another shade to them. These effects, spoken of as successive, may be also simultaneous. If a bright red spot be intently looked upon for two or three minutes, and the eyes then moved so as to receive the rays from a neutral colour, as grey, they will perceive a green circle for a moment or two; or if the red spot be surrounded by a neutral colour, and intently looked at, the eyes perceive a green ring round the red. These facts, which it is not in the scope of this work to enter more largely upon, are deserving of close attention from every person concerned in applying colours to cloths, and especially in printing, where several colours are applied together. Set rules upon colours which are best in presence of one another would be superfluous; the eye is the only referee and judge, and it would be useless to prescribe laws for it. A fine taste may be instructed and assisted by rules, but it generally makes the rules. Colour mixers ought to have some acquaintance with the laws of simultaneous contrast, in order to meet the requirements of business. They know already that a blotch chocolate, for example, or a black, which suits a crimson object, does not look well with a green or olive object; and long experience and expensive trials have caused them to know what shades are best; but very few understand the philosophical principles which these phenomena indicate, and they are speedily at the end of their information. Nothing seems to puzzle an inexperienced colour mixer so much as to find that the same chocolate ground looks green on one pattern, purple on another, and red on another; the influence of the other colours not being taken into account. Nothing would be easier than to make the ground colour suitable for the pattern if he was only aware of the optical effects of the other colours entering into the design.

It may be stated as a general rule that a colour is optically under the best circumstances when it is surrounded by a due proportion of its complementary; two such colours reflect to their mutual advantage. For the simple shades it is easy to compose the complementary, but for the compound shades it requires much ability and a good eye. The rule given, however, always holds good, viz., the complementary colour is that which the real colour is short of to make it into white. Here are a few colours with their complementaries:—

COLOUR.	COMPLEMENTARY.
Red.	Green = Blue + Yellow.
Yellow.	Purple = Red + Blue.
Blue.	Orange = Red + Yellow.
Green = Blue + Yellow.	Red.
Orange = Red + Yellow.	Blue.

Such a list might be made infinite if the nomenclature of colours was in a state to permit of it. Purple is the name of a colour which may range through fifty shades between the red and blue, and there is no language to indicate the precise shade. The subject is wrapped in still greater difficulty when it is a question of such shades as peach, pearl, grey, dove, lilac, drab, brown, and the like; and yet these are the colours most in use, and which require, more than the simple ones, the art and taste of the colourist to make them pleasing and beautiful in contrast with other colours.

Chemical Actions of Light.—Light seems to be a chemically active agent, inducing decompositions and changes in salts and neutral substances. It either acts itself, or its presence is the cause of action in numerous cases interesting to the dyer. I do not know what credit should be given to the assumed importance of bright light in dyeing colours of the finest quality. It is pretended that if all other things are equal, the brightness or dulness of the daylight influences the product of the dyeing. It is well known that plants which grow in dark places are pale coloured, and that the most sunny climates produce the brightest colours in the vegetable and animal kingdom. But there is nothing in the case of a growing plant or animal comparable to dyeing. In the one case the colour is being formed, in the other it is only being transferred. It is within the bounds of possibility that a formation of colouring matter may take place sometimes in dyeing, but I know of no case where this is effected by light. In nearly all colouring matters used in the arts, the colour is fully developed before the dyer uses it, and it is interesting to consider in how many cases without the access of light; the heart of logwood cannot be supposed to have been influenced directly by the rays of light; we know that the colour of indigo is only developed after the death of the plant; and in madder root the colouring matter must have been formed in perfect darkness. Yet practical dyers insist that the finest colours can only be produced in good clear weather; the most beautiful dyed silks and velvets of France are, I am told, produced by small dyers, who perform the final operations in clear bright weather and out of doors, turning the goods over and over in the dye, lifting them to meet the sun's rays, and, regardless of prescribed times and quantities of material, handling them till they find them finished.

Whatever doubts may be entertained upon the beneficial effect of light in certain circumstances, there can be none as to its destructive action upon colouring matters, under almost any circumstances, when prolonged beyond a short time. In most cases of rapidly fading colours,

such as safflower pink on cotton, or archil and cudbear shades upon silk, it is the light and not the air which destroys them, or at least the light is the more rapidly destructive of the two; the direct rays of the sun, being the most concentrated form of light, are the most active, but a bright diffused light is very energetic. A safflower pink on muslin may become nearly white in three or four hours' sunshine, and a peach-coloured silk ribbon, dyed with archil, is destroyed in about the same length of time. That it is the light, is demonstrated by the preservation of the colour in the folds, or protected parts of knots and bows formed by the material; the air could have access to these almost as readily as to the exterior portions, but they are nearly uninjured. Light is an imponderable body, and as such, leaves no marks behind it detectable by the balance. It is not clear whether these transformations are simply a change in the chemical or molecular structure of the colouring matter, or whether the light induces an oxidation or deoxidation of the colouring principles. The first view seems the most probable, from the knowledge we have of the action of light upon chemical substances, though the second is not without probability. The action of light upon substances in general may be profitably studied by the colourist; it seems probable that some means of protecting these easily alterable colours may be devised from a knowledge of the laws and properties of light. The action of light upon the salts of gold and silver is the foundation of photographic art, and many curious particulars have been discovered in it with regard to sensitivising, and, if the expression is allowable, desensitivising, the layer of silver salt. The deposited iodide or chloride of silver is so easily acted upon by light, as to necessitate the greatest precautions in keeping out a single ray from the closet in which the processes are conducted; but if the light be made to pass through a yellow medium, such as stained glass, it loses all its active chemical properties, and the prepared plates may be exposed to it and handled with the greatest ease and safety. There are other cases in which an additional film of another material renders the sensitive one insensible to the action of light. It is possible that the very delicate and fugitive vegetable colours may, by some practical process, be similarly desensitised. This is a line of research very difficult, no doubt, but in which there is both hope of success and rich reward.

Photography has not yet any application in calico printing, but it may be interesting to know, that it is possible to print pictures by photography and dye them up in madder and other dyewoods. I have done this several times and in several ways with iron salts. Calico may be prepared with the ammonia-citrate of iron, dried in the shade, and

then covered with the object or picture, and exposed to the rays of the sun in a photographer's copying press; the iron is partially fixed upon those parts exposed to light, the calico may be then passed in yellow prussiate, which forms Prussian blue with the iron fixed; this can be decomposed by dilute caustic alkali, leaving the oxide of iron, which, by boiling in cow dung, becomes fit for taking up dyes, and with madder gives a lilac or purple. The bi-chromate of potash is decomposed by light in contact with calico, washing in water removes the unchanged bi-chromate, the remainder may be fixed by dilute alkali, and forms a weak mordant for several dyewoods. Indigo blues, padded in bi-chromate of potash for discharging with acid, must be kept from strong direct light, on account of its decomposing action upon the bi-chromate.

ELECTRICITY AND MAGNETISM.

These interesting branches of physics have little or no known bearing upon dyeing or printing at this time, nor any sufficient probability of being so applied, that would justify entering upon these matters in this volume. In the earlier days of electro-metallurgy it was proposed to deposit some of the metals upon cloth; and means were devised by which a layer of copper could be fixed upon calico, and even a design produced. But, as may be easily imagined, this did not answer any useful or ornamental purpose, and the process has fallen into disuse. It is sufficient to indicate this to show that a possible application of electricity still lies in this direction. Attempts have been made to plate iron rollers with copper to economise the latter metal, but with very little success up to the present time.

SPECIFIC GRAVITY OR WEIGHT.

The number representing the specific gravity of a body indicates the weight of a given volume of it compared with the same bulk or volume of any other body. The numerical value is empirical, and by itself means nothing; it is only when it is known what body has been taken as a standard that the figures have a value. Water is taken as the standard with which all solid and fluid bodies are compared—it is reckoned either as unity or as a thousand unities. As the density of water varies at various temperatures, it is customary to take it at its greatest density, that is at 39.3° Fahr. or 4° Cent., but there are many cases in which it is taken at 60° Fahr., which is usually reckoned as the

English mean temperature. The specific gravity of gases differing very much from that of water, it has been found convenient to take another standard, and that is atmospheric air; it is reckoned either as unity or a thousand unities. In the arts specific gravity is used as a test for the quality of many articles, and the means taken to determine it become of interest, and should be well understood.

Specific Gravity of Solids.—There are two good methods which may be used to determine the specific gravity of a solid body:—(1) To weigh it in water, and out of water, by means of a good balance provided with a short scale pan and hook for the purpose. The weight of the body in air, divided by the loss by weight in water, gives the specific gravity of the substance. (2) If the solid be in powder, or small lumps, its specific gravity can be ascertained by taking a weighed quantity of it and adding it to a small vessel quite full of water; it displaces a certain quantity of water, the weight of which, divided into the gross weight of the substance, gives its specific gravity. For example, a piece of iron weighed in air 501.8 grains, and in water 435.5 grains, the loss of weight being 66.3 grains; the specific gravity = $\frac{501.8}{66.3} = 7.569$. The two processes depend upon the

same principle, viz., an indirect determination of the weight of a volume of water equal to that of the solid material taken. In the first instance it is obtained by its pressure upon the solid lowering its apparent weight, in the second by the solid throwing its own volume out of the already full bottle.

Specific Gravity of Fluids.—There are several ways of ascertaining the density of fluids. Amongst others may be enumerated:—(1) Weighing a glass bulb in the fluid to be examined; (2) weighing a given bulk of the fluid, the weight of the same bulk of water being known; (3) ascertaining the buoyancy of the fluid by solids of a known specific gravity, which case includes hydrometers. The first plan is the most delicate, but only applied to philosophical purposes. The second is one easily accomplished by means of small flasks sold as specific gravity bottles; they are made to hold exactly five hundred or one thousand grains, or some other determined quantity of pure water. The fluid to be examined being placed in the flask is weighed by the balance, and its density determined easily. If the flask hold a thousand grains of water, the quantity of any other fluid it holds is its specific gravity, water being a thousand; as for example, a thousand grains specific gravity flask holds 1,845 grains of strong sulphuric acid, the specific gravity of the sulphuric acid is

therefore 1,845, water being 1,000, or 1.845 water being unity. Where the specific gravity bottle holds less or more than just a thousand grains it requires a calculation to bring out the true specific gravity, the formula for which is $\frac{w \times 1000}{c}$ = specific gravity ; w being the weight

of the bottle full of the liquid, and c its capacity for pure water. For exact experiments the weight of pure water which the bottle contains should be ascertained, and not taken for granted on the maker's statement. Two specific gravity bottles, which I used, and which were represented as five hundred grain bottles, contained respectively 499.3 and 501 grains of pure water, at 60° Fahr., and these may be reckoned as good bottles, the errors not leading to any serious mistakes in practical operations, though quite unfit for scientific determinations.

There are small balls of glass sold, which serve in some cases for ascertaining the density of solutions ; they are made of different densities, and marked with the density. Several of them being thrown into a saline solution, some will fall to the bottom of the fluid because they cannot displace an equal weight of it ; others will swim on the top, because an equal weight of the fluid is less in volume than they are ; and possibly one of the balls will hang in the fluid, without any disposition to either rise or sink. This one will have the same specific gravity as the fluid, for it displaces exactly its own weight.

The use of the hydrometer, which is the sole ordinary instrument employed for ascertaining the density of fluids, is founded on the same principle as the glass balls. It indicates the weight of the volume of fluid which it displaces : but a part of the instrument being out of the fluid, as well as a part in, it is capable of indicating several various weights displaced, and one instrument can thus combine in itself a considerable range of density. There is, practically, a limit put to the range of a single instrument by the necessity there is of having small differences of density distinctly indicated to the eye ; and, though it is possible to have all the ranges of densities between water and strong sulphuric acid upon one spindle, it is found best to divide them among six different ones ; this division enables half and quarter degrees to be read off with ease. It is Twaddle's hydrometer which is exclusively used in England and Scotland, and the remarks here made are applied to it specially when graduation is spoken of. The six spindles indicate from water, as zero, to the density of concentrated sulphuric acid, or a little higher, generally not higher than the 170th degree. The graduation of the second spindle commences where the first ceases, and so on. The instrument will be more delicate in its indications as the

bulb under water is larger and the stem above thinner; a stem should not be less than six inches long in the graduated portion, including about thirty degrees. Hydrometers should be tested by liquids of known density; there are some sold whose indications are false to a great degree. I give the results of a testing of a set of six hydrometers, obtained from a respectable house in Manchester:—

NO. OF HYDR.	LIQUID USED.	DEGREE.	SPEC. GRAV.	SPC. GRAV. BY ANO. METHOD.
1	Dilute sulphuric acid....	7½	1.037	1.036
2	Alkaline pink liquor....	34	1.170	1.168
3	Caustic soda.....	71	1.355	1.352
4	Chloride of manganese...	80	1.400	1.396
5	Bi-chloride of tin.....	120	1.600	1.596
6	Sulphuric acid....	168	1.840	1.840

ADDITIONAL TESTINGS OF NUMBER ONE HYDROMETER.

LIQUID USED.	DEGREE.	SPEC. GRAV.	SPC. GRAV. BY ANO. METHOD.
Dilute sulphuric acid.....	10½	1.051	1.050
Dilute sulphuric acid.....	14	1.070	1.068
Dilute sulphuric acid.....	19	1.095	1.091

The specific gravities in the fifth column are the true specific gravities, those in the fourth being the indications of the hydrometer. This set of hydrometers was very good, the discrepancies between the fourth and fifth columns being very slight, and such as are generally exceeded by errors of manipulation.

The relation between the indications of Twaddle's hydrometer and the usual specific gravity figures, is obtained by a simple arithmetical calculation. To obtain the value of any degree of Twaddle, it must be multiplied by five, and the product added to 1,000, this gives the specific gravity taking water as 1,000, if water is to be taken as unity three places of decimals must be pointed off. The table above will furnish sufficient example to illustrate this rule.

COMPARISON OF THE SCALES OF VARIOUS HYDROMETERS.

Although Twaddle's hydrometer is now exclusively used in England for liquids heavier than water, it is not much known on the continent. The chief hydrometers in use in France, Holland, and Germany, are those of Beaumé, Beck, and that prescribed by the Dutch pharmacopœia. It has been deemed advisable to give tables, showing the comparative value of these various instruments in relation to Twaddle's, and to the true specific gravity, because receipts arriving from abroad have the

strength of these liquors given in one or other of these scales. Beaumé's hydrometer is the one in most common use upon the continent; in French works upon Technology and in manuscript receipts it is indicated by the letter B following the figure. There is no direct easy relation between its figures and real specific gravity numbers. Its scale was fixed by taking the point at which the instrument floated, in a mixture or solution of 15 parts of common salt and 85 parts of water. But no record has been left of the temperature of the solution, or of the quality of the salt employed, which, if ordinary culinary salt, is subject to great variations, and it remains uncertain whether an instrument graduated upon such a scale now would correspond to the original one.

In the table there are two columns, *a* and *b*, both for the specific gravity and the Twaddle value of a degree of Beaumé; those values under *a* were made by observation from a real instrument, those under *b* are calculated by a mathematical formula. They differ considerably in the higher degrees, and it is difficult to say which should be taken in a doubtful case. Probably it would be safest to take those under *b*, as representing the mathematically correct density, corresponding to which it is probable the best instruments will be made to agree.

TABLE SHOWING THE CORRESPONDENCE BETWEEN BEAUME'S HYDROMETER, TWADDLE'S HYDROMETER, AND SPECIFIC GRAVITY, WATER = 1,000.

BEA.	SPEC. GRAV.		TWADDLE		BEA.	SPEC. GRAV.		TWADDLE	
	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>		<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>
0	1000	1000	0	0	30	1246	1256	49	51
1	1007	1007	1½	1½	32	1267	1278	53	55½
2	1013	1014	2½	3	34	1288	1301	57½	60
3	1020	1021	4	4	36	1310	1324	62	65
4	1027	1028	5	5	38	1333	1348	65½	69½
5	1034	1035	7	7	40	1357	1374	71½	75
6	1041	1043	8	8	42	1382	1400	76½	80
7	1048	1050	9½	10	44	1407	1427	81½	85½
8	1056	1058	11	11½	46	1434	1455	87	91
9	1063	1065	12½	13	52	1520	1547	104	109½
10	1070	1072	14	14½	54	1551	1581	110	116
12	1086	1089	17	18	56	1583	1615	116½	123
14	1101	1105	20	21	58	1617	1652	123½	130½
16	1118	1122	23½	24½	60	1652	1690	130½	138
18	1134	1140	27	28	62	1689	1730	138	146
20	1152	1157	30	31	64	1727	1771	145½	154
22	1169	1176	34	35	66	1767	1815	153½	163
24	1188	1195	37½	39	68	1810	1861	162	174
26	1206	1215	41	43	70	1854	1909	—	—
28	1226	1235	45	47	72	1900	1960	—	—

Beck's Hydrometer.—This instrument is used in parts of France and Germany ; it was graduated by taking the points at which it floated in spirits of density 0.850 and pure water, dividing this space into thirty divisions, and carrying them equally on both sides of the zero for liquids heavier or lighter than water. Only so much of this hydrometer as is used for liquids heavier than water is given in the following table :—

TABLE SHOWING THE CORRESPONDENCE OF BECK'S HYDROMETER WITH TWADDLE'S AND SPECIFIC GRAVITY.

BECK'S.	SP. GR.	TWAD.	BECK'S.	SP. GR.	TWAD.	BECK'S.	SP. GR.	TWAD.
1	1006	1	22	1148	29½	52	1440	88
2	1012	2½	24	1164	33	54	1465	93
3	1018	3½	26	1180	36	56	1491	98
4	1024	5	28	1197	39½	58	1517	103½
5	1030	6	30	1214	43	60	1545	109
6	1036	7	32	1231	46	62	1574	115
7	1042	8½	34	1250	50	64	1603	120½
8	1049	9	36	1268	53½	66	1634	127
9	1055	11	38	1287	57½	68	1666	133
10	1062	12½	40	1307	61½	70	1700	140
12	1075	15	42	1328	65½	72	1734	147
14	1089	18	44	1349	70	74	1770	154
16	1103	20½	46	1371	74	76	1808	161½
18	1118	23½	48	1393	78½	—	—	—
20	1133	26½	50	1416	83	—	—	—

Dutch Hydrometer.—The hydrometer of the Dutch Pharmacopœia is in use in Holland and the neighbouring countries. It was graduated by taking one part of common salt in ten parts of water, and dividing the difference of the points at which it stands in this solution, and in pure water into ten degrees.

TABLE SHOWING THE CORRESPONDENCE BETWEEN THE HYDROMETER OF THE DUTCH PHARMACOPŒIA AND TWADDLE'S HYDROMETER.

DUTCH.	SP. GR.	TWAD.	DUTCH.	SP. GR.	TWAD.	DUTCH.	SP. GR.	TWAD.
0	1000	0	20	1161	32	50	1532	106½
1	1007	1½	22	1180	36	52	1566	113
2	1014	3	24	1199	40	54	1601	120
3	1022	4½	26	1221	44	56	1637	127½
4	1029	6	28	1242	48½	58	1676	135
5	1036	7	30	1261	52	60	1714	143
6	1044	9	32	1286	57	62	1758	151½
7	1052	10½	34	1309	62	64	1801	160
8	1060	12	36	1334	67	66	1847	169
9	1067	13½	38	1359	72	68	1897	—
10	1075	15	40	1384	77	70	1946	—
12	1094	18	42	1412	82½	72	2002	—
14	1106	21	44	1440	88	74	2059	—
16	1125	25	46	1470	94	—	—	—
18	1143	28½	48	1501	100	—	—	—

There are a few other hydrometers in use in Europe, but not of sufficient importance to require mentioning here. For the value of the chief continental hydrometers, Gerstenhöfers Hülfsbuch may be referred to; it is from that source that the materials of the foregoing tables have been obtained.

In the case of hydrometers and all other methods of determining densities, the temperature of the solution must be attended to. The English hydrometers are graduated at a mean temperature of 60 deg. F. If the fluid be warmer than this at the moment of testing it will appear weaker, and if colder, stronger than it is at the intermediate temperature. A difference of ten degrees of heat in either direction will not make much difference in the usual applications of the hydrometer.

Specific Gravity of Gases and Vapours—This is a subject which need not occupy room here, as the cases in which the relative density of any gases has to be determined in a print works must be very rare; it will be sufficient to state that the method followed is similar to the specific-gravity-bottle plan for liquids; a flask of known capacity is filled with the gas, and from its weight, as compared with the same flask full of air, the specific gravity of the gas is calculated.

For purposes of reference, I give here, from good authorities, a tolerably full table of specific gravities of solids, fluids, and gases.

SPECIFIC GRAVITY OF SOLID BODIES—WATER = 1.

Alum.....	1.71—1.75	Ice.....	0.92
Alumina.....	1.10—1.74	Iron, wrought.....	7.6 —7.8
Antimony.....	6.65	„ cast.....	7.0 —7.5
Arsenic acid.....	3.70	„ peroxide.....	4.93—5.25
Arsenic.....	5.77—5.96	„ protoxide.....	3.50
Arsenious acid.....	3.38	„ sulphate.....	1.83—1.97
Asphaltum.....	1.07—1.60	Ivory.....	1.83—1.92
Baryta.....	3.30—4.80	Lime, quick.....	1.27—2.30
Building stone average.....	2.50	Limestone.....	2.40—2.84
Borax.....	1.72	Lead.....	11.33
Brazil wood.....	1.03	„ acetate.....	2.35
Box wood.....	0.91—1.33	„ sulphate.....	6.30—6.7
Baryta chloride.....	2.82	Magnesia.....	2.13—2.35
„ sulphate.....	4.41	Magnesite.....	2.81—3.0
Bones (ox).....	1.66	Magnetic ore.....	5.09
Brass, cast.....	8.40—8.71	Magnesia sulphate.....	1.75
Bismuth, cast.....	9.82	Manganese.....	8.01
Brick.....	1.40—2.3	Manganese peroxide.....	4.32
Calcium chloride.....	2.21	Marble.....	2.5 —2.8
Chromium.....	5.90	Mercury, frozen.....	14.40
Chrome iron ore.....	4.30—4.50	„ oxide.....	11.08
Chromium oxide.....	2.50—2.60	„ protoxide.....	12.07
Copal.....	3.85	Mercury, bi-chloride.....	5.14
Charcoal, pine wood.....	0.28—0.44	Phosphorus.....	1.70—1.77
„ oak.....	0.57	Phosphoric acid.....	2.68
Cadmium, cast.....	8.60	Platinum, melted.....	20.90
Cobalt, rolled.....	9.15	Potassium.....	0.86
Cobalt ore.....	6.29	Potassium chloride.....	1.83
Chalk.....	2.25—2.68	„ iodide.....	3.07
Copper, cast.....	8.67—8.90	„ carbonate.....	2.60
Copper pyrites.....	5.70	„ sulphate.....	1.73—2.63
Copper oxide.....	6.09—6.40	Realgar.....	3.30
„ sulphate.....	2.19	Rhodium.....	11.00
Diamond.....	3.50	Sal-ammoniac.....	1.45—1.53
Earth, loamy moist.....	2.05	Saltpetre.....	1.94—2.00
„ dry.....	1.93	Sand, fine and dry.....	1.40—1.64
„ garden moist.....	2.05	Slate.....	2.64
Fernambouc wood.....	1.01	Sulphur, refined.....	1.98
Fat of animals.....	0.92	„ native.....	2.07
Flint.....	2.59	Silver, cast.....	10.47
Glass, bottle.....	2.73	„ hammered.....	10.51
„ flint.....	3.20—3.78	„ oxide.....	7.14
Gold, native massy.....	14.6—19.1	Starch.....	1.53
„ coined.....	19.35	Steel.....	7.26—7.80
Graphite.....	1.8 —2.24	Stearine.....	0.96
Gum arabic.....	1.31—1.45	Stearic acid.....	1.01
Indigo.....	0.73	Strontian.....	3.40
Iodine.....	4.94	Sugar, cane.....	1.60

Sugar, milk.....	1.54	Tin, hammered.....	7.3 —7.48
Strontian carbonate	3.6 —3.8	Tartaric acid.....	1.59—1.75
Strontium	4.0 —5.0	Uranium.....	9.00
Sodium	0.93	Wax	0.97
„ chloride	2.10	Zinc, cast	6.86—7.22
Soda hydrate.....	1.53	„ hammered	7.19—7.21
„ carbonate	1.42	„ oxide	5.43
„ sulphate.....	2.24	„ chloride.....	1.57
„ acetate.....	2.10	„ sulphate	2.03
Tin, cast	7.18	„ nitrate.....	2.09

SPECIFIC GRAVITY OF SOME FLUID BODIES—WATER = 1.

Alcohol absolute.....	0.792	Olive oil.....	0.915
Ammonia liq.....	0.875	Poppy oil.....	0.924
Acetic acid, concentrated.....	1.063	Rape oil.....	0.914
Beer	1.023	Sea water.....	1.02 to 1.04
Bromine	2.966	Sulph. acid, concentrated	1.850
Bi-sulphuret carbon.....	1.272	Sulphuric acid, Nordhau-	
Coal naphtha	0.770	sen	1.860
“ rectified	0.911	Turpentine, spirits.....	0.79 —0.890
Ether.....	0.716	“ rectified.....	0.860
Linseed oil.....	0.940	Water, distilled	1.000
Muriatic acid, concentrated.....	1.200	Wine, Rhine.....	0.99 —1.000
Mercury.....	13.598	Champaigne.....	0.96
Nitric acid, red.....	1.522	Madeira.....	1.038
Nitric acid, ordinary strong.....	1.410		

SPECIFIC GRAVITY OF SOME GASES AND VAPOURS—AIR = 1.

Ammonia.....	0.597	Carburetted hydgn. marsh gas...	0.559
Arseniuretted hydrogen	2.695	Hydrogen.....	0.069
Air, atmospheric.....	1.000	Nitrogen.....	0.975
Bromine	5.40	Iodine	8.716
Chlorine	2.440	Oxygen.....	1.105
Chlorhydric acid	1.247	Phosphorus	4.580
Cyanogen.....	1.822	Sulphur.....	6.034
Carbonic oxide.....	0.977	Sulphuretted hydrogen	1.191
Carbonic acid.....	1.529	Sulphurous acid	2.193
Carburetted hydrogen, heavy.....	0.985	Water	0.623

French Weights and Measures.—The reason which induces the author to give the value of the continental hydrometers seems to render it desirable that the weights and measures of France should have some notice in this place. The French weights and measures are upon a philosophical system, and are all connected together. The kilogramme is the commercial unit in weight, and the litre in measure: a litre of water weighs one kilogramme. The fractional parts are expressed by the decimal system; half a kilogramme is

0.5k, a quarter kilogramme is 0.25k, and so on. Here is a receipt from the work of M. Persoz ; it is for a chocolate upon delaine :—

10 lit. sapan extract, at 10° B. (Beaumé).
 5 lit. berry liquor, at 10° B.
 4.160 lit. logwood liquor, at 10° B.
 1.538 kil. alum.
 0.320 kil. sal ammoniac.
 0 426 kil nitrate of copper.
 8.880 kil. gum senegal.

This receipt is evidently a too close translation from some foreign source, or else from a provincial works in France where pots, pounds, and ounces have so far resisted the new weights and measures. Carrying the weights of the alum and nitrate of copper to the third place of decimals is an affectation of nicety quite unknown in practice when operating upon 20 litres of colour. To transpose the above receipt by means of the tables proceed as follows :—10 litres are found at once to be equal to 17 pints and one-half ; the 4.160 litres are made up of 4 litres, equals 7 pints ; 0.1 litre equals 3½oz., and 0.06 litre equals 2oz. ; together making 7 pints 5½oz. Taking the alum, we find—

1 kilogramme	=	2lbs. 3¼oz.
0.5 ,,	=	1lb. 1¼oz.
0.03 ,,	=	0lb. 1oz.
0.008 ,,	=	0lb. 0¼oz.
		3lbs. 6oz.

The 1.538 kilogrammes are therefore equal to 3lbs. 6oz. The same method pursued with regard to the remaining items would give the receipt as follows, consulting the table on page 12 for the Twaddle equal to 10° B. :—

17½ pints sapan liquor, at 14° Tw.
 8½ pints berry liquor, at 14°
 7 pints 6oz. logwood liquor, at 14°
 3lbs. 6oz. alum.
 11oz. sal ammoniac.
 15oz. nitrate of copper.
 20½lbs. gum senegal.

A greater closeness than is used above would be useless, and even as it is, a practised colour mixer would give it a more English and manageable shape without injuring the colour.

TABLE SHOWING THE VALUE OF A KILOGRAMME, FROM 0.01 UPWARDS, IN AVOIRDUPOIS POUNDS, AND OUNCES.

KILO.	OUNCES AVOIR. IN DECIMALS.	NEAREST PRAC- TICAL WEIGHT.		KILO.	OUNCES AVOIR. IN DECIMALS.	NEAREST PRAC- TICAL WEIGHT.	
		Lbs.	Oz.			Lbs.	Oz.
0.01	0.352	0	$0\frac{1}{3}$	0.60	21.12	1	5
0.02	0.704	0	$0\frac{3}{4}$	0.70	24.64	1	$8\frac{1}{2}$
0.03	1.056	0	1	0.80	28.16	1	12
0.04	1.408	0	$1\frac{1}{2}$	0.90	31.68	2	0
0.05	1.760	0	$1\frac{3}{4}$	1.00	35.20	2	$3\frac{1}{4}$
0.06	2.112	0	2	2.00	70.40	4	7
0.07	2.464	0	$2\frac{1}{2}$	3.00	105.60	6	$9\frac{1}{2}$
0.08	2.816	0	$2\frac{3}{4}$	4.00	140.80	8	$12\frac{3}{4}$
0.09	3.168	0	3	5.00	176.00	11	0
0.10	3.520	0	$3\frac{1}{2}$	6.00	211.20	13	3
0.20	7.040	0	7	7.00	246.40	15	$6\frac{1}{2}$
0.30	10.560	0	$10\frac{1}{2}$	8.00	281.60	17	$9\frac{1}{2}$
0.40	14.080	0	14	9.00	316.80	19	$12\frac{3}{4}$
0.50	17.600	1	$1\frac{1}{2}$	10.00	352.00	22	0

TABLE SHOWING THE VALUE OF A LITRE, FROM 0.01 UPWARDS, IN IMPERIAL PINTS AND FLUID OUNCES.

LITRE.	AVOIRDUPOIS	PRAC. EQVT.		LITRE.	AVOIRDUPOIS	PRAC. EQVT.	
		Pts.	Oz.			Pts.	Oz.
0.01	0.352	0	$0\frac{1}{3}$	0.60	21.12	1	1
0.02	0.704	0	$0\frac{3}{4}$	0.70	24.64	1	4
0.03	1.056	0	1	0.80	28.16	1	8
0.04	1.408	0	$1\frac{1}{2}$	0.90	31.68	$1\frac{1}{2}$	2
0.05	1.760	0	$1\frac{3}{4}$	1.00	35.20	$1\frac{1}{2}$	5
0.06	2.112	0	2	2.00	70.40	$3\frac{1}{2}$	0
0.07	2.464	0	$2\frac{1}{2}$	3.00	105.60	5	6
0.08	2.816	0	$2\frac{3}{4}$	4.00	140.80	7	0
0.09	3.168	0	3	5.00	176.00	$8\frac{1}{2}$	0
0.10	3.520	0	$3\frac{1}{2}$	6.00	211.20	$10\frac{1}{2}$	0
0.20	7.040	0	7	7.00	246.40	12	6
0.30	10.560	$0\frac{1}{2}$	$0\frac{1}{2}$	8.00	281.60	14	$1\frac{1}{2}$
0.40	14.080	0	14	9.00	316.80	$15\frac{1}{2}$	0
0.50	17.600	0	$17\frac{1}{2}$	10.00	352.00	$17\frac{1}{2}$	2

NOTE.—In the two tables showing the values of the litre and kilogramme in English weights and measures, it is not the exact English equivalent which is given, but the nearest that the weights and measures in common use allow; sometimes above sometimes below the real amount, but never more than a quarter of an ounce either way.

THE CHEMICAL ELEMENTS.

As far as our knowledge extends, the whole earth, with all it contains, is composed of about sixty different substances, which are called elements or simple bodies. There is nothing, either animate or inanimate, which is not composed of one or more of these sixty elements. The science of chemistry consists in a knowledge of the nature and properties of these elements, and the innumerable compounds which they form with each other. Each element can combine with some other of the elements, and mostly with every other one. These simple compounds form others between themselves, giving rise to that immense variety of natural and artificial substances which are known to the chemist. As the twenty-six letters of the alphabet are at the basis of every word in the language, so are the sixty elements the basis of all visible nature. An element is a simple undecomposable body, composed of only one material—such is gold for example. Whatever process gold may be submitted to, however much it may be altered in appearance, no art nor skill can make anything but gold out of it, nor can a particle of it be destroyed. At the end of any imaginable operation to which it may be submitted, the gold can be all recovered, just the same in value and properties as when it was first taken. It is not the same with any mineral which may be picked up, or with a piece of wood. Most minerals can be easily shown to be divisible into several bodies, and if wood be burned there is no possibility of making wood again out of the vapours which have arisen from it.

The following list contains the names of all the elementary bodies known; they are arranged in alphabetical order, and before each element is placed a letter or letters which is the symbol of the element, or a contraction used to facilitate explanations of chemical combinations and decompositions. The figures under the head of equivalent weights indicate the relative proportions in which the elements combine with each other; thus, the figure 8 before oxygen, and 103.5 before lead, intimate that those elements may combine in those quantities, and so on with the rest. M. Dumas has recently investigated the equivalent weights of many of the elements, and as the determinations of this eminent chemist are more likely to be correct than those of older authorities, I have adopted them in preference, when there was any difference. A few of the elements are so little known as not to have either symbols or equivalent weights yet assigned to them.

NAMES OF THE ELEMENTS WITH THEIR SYMBOLS AND EQUIVALENT
WEIGHTS.

NAMES OF ELEMENTS.	SYMBOL	EQUIV.	NAMES OF ELEMENTS.	SYMBOL	EQUIV.
Aluminum.....	Al.	13.75	Nickel	Ni.	29.5
Antimony	Sb.	122.	Niobium	—	?
Arsenic	As.	75.	Nitrogen.....	N.	14.
Barium	Ba.	68.5	Osmium	Os.	99.5
Bismuth.....	Bi.	210.	Oxygen	O.	8.
Boron.....	B.	11.	Palladium	Pd.	53.4
Bromine.....	Br.	80.	Pelopium.....	Pe.	?
Cadmium	Cd.	56.	Phosphorus.....	P.	31.
Calcium	Ca.	20.	Platinum	Pt.	98.8
Carbon	C.	6.	Potassium	K.	39.2
Cerium	Ce.	46.0	Rhodium	R.	52.2
Chlorine.....	Cl.	35.5	Ruthenum	Ru.	?
Chromium	Cr.	26.2	Selenium.....	Se.	39.75
Cobalt	Co.	29.5	Silicium	Si.	14.
Copper.....	Cu.	31.7	Silver.....	Ag.	108.
Didymium.....	—	?	Sodium	Na.	23.
Fluorine.....	Fl.	19.	Strontium	Sr.	43.75
Glucinum.....	Gl.	26.5	Sulphur	S.	16.
Gold	Au.	99.4	Tantalum.....	Ta.	92.4
Hydrogen	H.	1.	Tellurium.....	Te.	64.5
Iodine.....	I.	127.	Thorium.....	Th.	59.6
Iridium	Ir.	98.8	Tin.....	Sn.	59.
Iron	Fe.	28.	Titanium	Ti.	24.3
Lanthanum	Ln.	44.4	Tungsten	W.	92.
Lead	Pb.	103.5	Uranium	U.	60.0
Lithium.....	Li.	6.4	Vanadium	V.	68.6
Magnesium.....	Mg.	12.	Yttrium.....	Y.	32.3
Manganese.....	Mn.	27.5	Zinc	Zn.	33.0
Mercury.....	Hg.	100.0	Zirconium.....	Zr.	33.6
Molybdenum	Mo.	48.			

The greater number of these elements are very rare, and consequently not employed in the arts, and for the most part do not seem capable of profitable application. It is not necessary, therefore, to enter into a minute study of them. The following list contains the names of all the elements which, either in themselves or their compounds, enter into the operations of the arts we are treating of. They are arranged in a certain natural order, the same as that in which they will be treated in the

following pages ; before each element is the name of some principal compound of it :—

Oxygen, Hydrogen, Nitrogen.	} These three elements combined in various proportions, produce water, air, ammonia, and nitric acid.
-----------------------------------	--

Carbon.....Coal and all vegetable substances contain carbon.

ChlorineChloride of lime.

Sulphur.....Sulphuric acid, or oil of vitriol.

SiliconSand, silicate of soda.

Potassium.....Potash.

SodiumSoda, soda ash.

Calcium.....Lime.

Aluminum.....Alum, acetate of alumina.

IronSulphate of iron.

Manganese....Oxide of manganese.

Chromium.....Chrome salts, bi-chromate of potash.

Arsenic.....White arsenic (arsenious acid), orpiment.

ZincOxide of zinc, sulphate of zinc, or white vitriol.

Tin.....Tin salts, stannate of soda.

Lead.....Acetate, or sugar of lead.

Copper.....Sulphate of copper, or blue vitriol.

Mercury.....Bi-chloride of mercury, or corrosive sublimate.

Any substance not in the list of elements will be a compound body, and will be treated upon under the head of one of the elements from which it is derived, and usually under that element which seems to give it its distinctive character, for example, sulphate of copper will be found described under copper, sulphuric acid under sulphur, chloride of lime under chlorine, &c. The vegetable substances are treated of in a distinct section, and under such an arrangement as is suitable to the plan of the work.

Chemical Equivalents.—Much profitable use may be made of the chemical equivalents when they are thoroughly understood, and the degree of purity of the chemicals in use known. With only an imperfect knowledge of the combinations and decompositions of salts, and want of information upon the value of the commercial articles supplied, but little good will result from the application of equivalent weights to practice. The numerous details upon this subject are not within the scope of this work ; such applications as are useful to the practical worker are detailed in their proper places.

Chemical Symbols and Nomenclature.—A few chemical symbols or

literal abbreviations are used where they facilitate the explanation of some decomposition or property of bodies : the symbols being known from the preceding list, their combinations are usually self-explanatory; when otherwise, they may be generally passed over without interfering with the connection of the remarks. The nomenclature of chemical compounds is in accordance with set rules, which will be more easily understood by the context than by a formal recitation of them. In the glossary of technical terms, their equivalents in common language, when they have such, are set down.

CHAPTER II.

WATER.

DISTILLED AND STEAM WATER—RAIN WATER—RIVER WATER—SPRING WATER—PURIFICATION OF WATER—CHEMICAL RELATIONS OF WATER—STEAM—THE CONSTITUENTS OF WATER—OXYGEN—HYDROGEN—OZONE—OXYGENATED WATER.

WATER is composed of the two gases—oxygen and hydrogen—in a state of condensation. These gases, not having any direct applications to the arts, and their properties not giving any information upon the characteristics of water, do not call for a detailed notice : they are referred to at the end of this chapter.

Perfectly pure water does not appear to exist in nature ; it is artificially prepared by distilling ordinary water, with several precautions, in vessels of silver or platinum. Steam is pure water in the gaseous state, and when it is condensed, the water obtained is pure. Ordinary steam, or condensed water, is subject to be contaminated by several impurities : iron from the pipes is sometimes found ; ammonia, from vegetable or animal matter present in the water ; and very generally a certain volatile oily matter, probably originating from the tallow or other grease used in the boiler, as well as impurities derived from the packings of the steam pipes. But when the pipes are well seasoned and the original water not very impure, steam water is nearly pure water, and for all practical purposes may be taken as such. All the natural sources of water are derived from rain, which is produced by the condensation of vapour originally rising from the waters of the ocean. This being a great natural distillation, it will be anticipated that rain water is the purest of all kinds of water. When carefully collected at a distance from human habitations, rain water only differs from the purest distilled water by containing minute quantities of organic matter, and

certain gaseous bodies which it has imbibed from the atmosphere. But the moment it touches the earth, its solvent powers are so considerable, that it is instantly contaminated with earthy matters to a greater or less degree, depending upon the nature of the ground. The impurities of water consist in the mineral or vegetable matters which it has extracted from the earth over or through which it has passed from its first fall. If the ground be composed of hard insoluble rocks, the water passes over or through them, taking up very little of their constituents in its passage, even though the contact may have been a prolonged one; such a water will be a soft and pure water, whether it flow as a river or rise as a spring. If, on the contrary, the ground be composed of substances dissolvable by water, the water will soon become saturated with the soluble principles; if a current of pure water meet a bed of rock salt it becomes brine; if it pass through or over a strata of limestone or selenite, it soon becomes charged with those substances constituting a hard, limy, or calcareous water. If the land from which the water drains be peaty or boggy, containing much vegetable matter, a small portion of this will be dissolved. Though the quantity of these adventitious matters is small when compared with the water itself, they influence its quality to a remarkable extent as a medium of communicating colours, and the greatest care is necessary in procuring the best supplies. Perfectly pure water would be the best for all manufacturing purposes, if it were procurable. The preference for any particular source of water is always traceable to the absence of injurious components, or to the fortuitous occurrence of some substance which acts as a corrective of a natural impurity, and not to the existence of the impurity itself. There are, however, some colours which can be dyed very well in water strongly impregnated with mineral matters, and it is thought with better results than in pure water; but in all known cases it is possible to add such chemicals to pure water so as to produce equally good results. But it is not possible so to remove the impurities from water, as to make it in every case equal to a naturally good supply. In making choice of a source of water, not only the quantity but the peculiar nature of the impurities must be taken into account. Some impurities are readily removed by filtration and exposure to the air, others are not affected by such a treatment; some can be readily purified by lime, others are not in the least improved by it; one class of impurities is injurious to one style of production, but not to another, and so on. As a general rule it may be laid down that river water, that is, surface drainage water, contains the least amount of mineral matters and the largest amount of vegetable matter, and that spring or

well water contains the greatest quantity of mineral substance, with a minimum of organic matter.

Up to the present time the following substances have been detected in natural waters :—

Acids.—Carbonic, sulphuric, sulphurous, nitric, phosphoric, boracic, silicic, and hydro-sulphuric.

Bases.—Soda, potash, lithia, ammonia, lime, magnesia, strontia, baryta, alumina, protoxides of iron and manganese, oxides of zinc and copper, tin, lead, silver, antimony, arsenic, nickel, and cobalt.

Also, not being bases, are found chlorine, bromine, iodine, fluorine, sulphur, and hydrogen.

Any given sample of water would only contain a few of the above substances, but it is possible for any of them to be there. The mineral substances mostly found in river, spring, and well water, are as follows :—

Lime, combined with carbonic acid, and with sulphuric acid, as bicarbonate and sulphate of lime ; *magnesia* combined frequently with muriatic acid, sometimes with carbonic acid ; *potash* and *soda* usually in very small quantities ; *iron* in the state of a carbonate held in solution by carbonic acid, or in some other form ; *silicic acid*, either in the acid state or combined with the potash, generally the former. Those which chiefly concern the dyer are the lime, the iron, and the magnesia, the remainder are of little consequence.

Lime in Water.—A practical man knows when his water contains lime by several phenomena, the most striking of which is the way in which it acts with soap : a calcareous water destroys the soap, throws it up as a curd, and does not give a lather until as much soap has been put in as takes up all the lime. All this soap is wasted, and may even injure cloth by adhering to it, not being washed off easily. But the soap test is not precisely a chemical test for lime, because there are many other substances which would act in the same manner ; but these substances are not likely to be present in water, unless it be magnesia, and this not often, so that whenever a water does curd soap, it may be looked upon as a sure indication of the presence of lime. The quantity of soap which a given bulk of water can destroy, is also a good test of the quantity of lime in the water ; it may be used roughly to compare two different waters, or the same water at different times ; an exact method of doing this is given further on. The reason why soap is destroyed by a hard water is, that being a compound of fatty matter with soda, the whole dissolves in pure water, but the fatty matter is

said to have a stronger desire to go to the lime than to remain with the soda ; and when in contact with lime it combines with it, leaving the soda, and because the compound of lime and fatty matter cannot dissolve in water, it rises as a greasy curd until all the lime is combined with the fatty matter. A hard water can be made soft for some purposes by the addition of soda ash, or soda crystals : if the water be brought to a boil after addition of soda, most of the lime will rise up as a scum to the surface, which must of course be taken off before any goods are entered. The proper chemical test for lime in water is the salt called oxalate of ammonia ; when a clear solution of this is poured into a water containing even a very small quantity of lime, it indicates it by producing a milkiness, which on standing, settles down as a white sediment, the quantity of this sediment or precipitate will be proportionate to the amount of lime in the water. But neither this nor the soap test will show what kind of salt of lime is in the water ; they show the same characters whether it be gypsum (sulphate of lime), chalk, or muriate of lime. Further tests are required to ascertain which is really present. If about a pint of water, containing lime salts, be boiled down in a glass flask until it is reduced to half a noggin, it will be seen that the water is turbid, and that the sides of the flask are covered with a white pellicle. This indicates that either sulphate of lime, or carbonate of lime, or both, are present : to the fluid in the flask let a few drops of spirits of salts be added ; if there is an effervescence and the liquid becomes quite clear, it shows that all the lime is present as carbonate of lime ; if there is no effervescence and no clearing of the liquid, it may be judged that it is sulphate of lime ; and if, as usually happens, there is an effervescence and only a partial clearing, it proves that there is a mixture of both salts of lime : to determine how much of each requires analytical processes. If there is no deposit or milkiness in the flask after the boiling down, either there is no lime at all, or else it is in the very unusual condition of muriate, or nitrate of lime.

With regard to the different actions of these two salts of lime, i.e. the carbonate of lime and the sulphate of lime, in dyeing, it may be said that they are both injurious to fine colours, but neither of them hurtful to saddened or dark colours, unless the water be impregnated to a very great extent. Carbonate of lime in water is thought to be advantageous in madder dyeing, especially with certain kinds of madder, and very frequently ground chalk is added to the water before dyeing with it to make up any deficiency. Sulphate of lime in considerable quantity is injurious to madder dyeing, and indeed to all kinds of dyeing with woods, causing a waste of colouring matter and giving inferior results ;

it is hardly possible to dye good bright light shades in such a water.

Magnesia in Water.—If the magnesia be in the water in the state of muriate, and not inclined to become carbonate by boiling (which it does if much carbonate of lime be in the water), it will not do any harm, the same if it exist as sulphate. But if it exist in the water as carbonate, or can be transformed to such, it may prove very detrimental indeed, completely preventing the dyeing of certain colours, and spoiling others; for example, madder mixed with one-fiftieth of its weight of calcined magnesia will not dye at all, and with one part to a hundred it is spoiled, but magnesia seldom exists in sufficient quantity to be so injurious. The tests for it are given further on.

Iron in Water.—Most waters contain a small quantity of iron; it usually exists as a bi-carbonate of iron; some waters contain so much that the stream is quite of a rusty colour, and the bottom and sides perfectly yellow with the iron rust which has deposited from the water. It is fortunate that this metal has a great tendency to fall out of water spontaneously, that is, simply by contact with the air, because many spring waters contain iron and are quite unfit for dyeing and bleaching purposes; but by a process of filtration and exposure to the air the iron may be completely separated. The best test for iron in water is tincture of logwood or logwood liquor; when a single drop of strong logwood liquor is put into a wineglass full of water free from iron, it gives either a sherry colour or a claret, depending upon the amount of lime present, but if there be any iron the colour changes to blue, blue black, and finally to inky black, depending upon the quantity of that metal contained in the water. This test must be judged of within a short interval of time, for if the glasses be left exposed to the air the logwood becomes altered, turning darker, and might be supposed to indicate iron when in reality there was none. In testing a spring water for iron in this way it is necessary that the water should be freshly drawn; if it be some days or even hours old, especially if it be carried far in a bottle, all the iron is thrown out as insoluble oxide, and the change of colour does not take place. The influence of a water holding iron in solution upon dyeing is very marked, it turns pinks into drabs, and reds into dull browns and chocolates; if much iron be present it prevents dyeing altogether, for the iron in the water combines with the colouring matters and the cloth receives none, or only a feeble proportion. An exaggerated specimen of a ferruginous water may be obtained for experiments from an iron steam pipe where condensed water has stood for a day or two; it will be quite clear and bright looking, but if left in an open

basin for a few hours the iron rust will be seen to separate, or if a bleached fent be dipped in it and hung up it will soon become of a light buff colour ; in such a water madder refuses to dye, all colours are injured except blacks and saddened shades, and under no circumstances will it leave the whites of printed cloth clear, or possible to be cleared, without almost destroying the dyed colour.

Other Substances in Water.—The potash and soda salts which often exist in water are usually without any marked effect in dyeing or bleaching, being present in very small quantities and generally of a neutral nature. The silicic acid, which is a frequent constituent of water, but in small quantities, is likewise without any marked action in dyeing ; from the author's experiments it appears that pure hydrated silicic acid is injurious in madder dyeing, but not strikingly so. The organic matter which is contained in some waters, and which has received the names of *crenic* and *apocrenic acid*, is not without influence in dyeing, but it is more in bleaching and especially in clearing printed goods that the presence of organic matter is troublesome. It prevents the brilliant white finish on bleached goods, and often in the *chemicking* causes them to take a yellow cast very difficult to remove. In clearing madder prints in the beck with solution of bleaching powder and water charged with organic matter, the reaction between the chemic and the vegetable matter, when the temperature is raised, causes the formation of a yellow or brownish matter, which falls upon the cloth and spoils the whites and is not easily removed ; at the same time the colour is injured. A good test for this condition of vegetable matter in water consists in taking about a pint of the water and mixing with it about half an ounce of clear bleaching powder solution standing at 2° Tw. and warming in a glass flask to about 160° F. ; if it goes yellowish, and in a short time deposits a buff coloured deposit, it may be considered certain that it is not fit to clear pieces by the old plan ; for clearing in the padding machine and steam box, much less water being used, it does not matter so much. Nitrate of Silver, Chloride of Gold, and Permanganate of Potash are also used as tests for the presence of vegetable matter in water.

PURIFICATION OF WATER.

Few works are so fortunately situated as to be able to use water without some purifying process, and none should be without the means of purifying in case of necessity, for the best streams are at times unfit for working with, and, unless filters are at hand, the works must stop

until the water comes clear again. The purifying agents to be employed are principally those of nature—exposure to air and light, and a straining out of suspended matters by filtration. The methods employed are too well known to need description in detail. The water from the source is led or pumped into a reservoir of size proportioned to the wants of the works, the larger the better, and preferably long and narrow, so that as much distance as possible may exist between the water coming in and that flowing out to the filters. This reservoir is meant to keep up a stock, and to allow mud, &c., to settle out; sometimes two are used alternating, to allow the water some hours of quietness. From this depositing reservoir the water goes on to the filters. The filter is essentially a bed of coarse sand, supported upon pebbles and boulders. The filtration being downwards, the water passes through the sand and on to the works by proper arrangements, as is well understood. The surface of the filters should be as large as the space at command will allow, both because they will then filter more water and filter it better. The sand acts partly as a strainer to keep back the mechanically suspended impurities, but its most important action is of another nature, the exposition of the water more completely to the action of the air. Each particle of sand becomes covered with a film of water so thin that the air can act very completely upon it, penetrating it, as it were, through and through. The vegetable, and some of the mineral impurities, are changed by the action of the air; they become insoluble in the water, and, instead of passing through the filter, they adhere to the particles of sand, in the form of a slimy, glairy substance. If the water be bad, this slime collects in such quantity as to stop the action of the filter, either not letting the water pass through at all, or letting it pass through without purifying it. The remedy consists in scraping the top sand off the filter deep enough to remove that portion saturated with impurities, when the filtration will go on again. The depth of sand required to filter well depends a good deal upon its quality or fineness, and the kind of water to be filtered. A bed twelve inches thick should be sufficient under all ordinary circumstances, and it should not be reduced to less than four inches by scraping. When the sand, after being used, is well washed with violent agitation, the impurities of the water are in a great measure detached, and it can be employed over again, but it is best to leave the washed sand several weeks exposed to the air before spreading it on the filters. When water is highly charged with vegetable impurities the filter does not seem to remove them, but, by paying attention to a few points, the water may generally be made useable. Firstly, as above stated, it is the air which purifies the water, the sand being the

instrument or apparatus for exposing the water to the air: the worse the water, the greater pains must be taken to let the air have access to it; the filter bed must not be overcharged with water, that is, it must not have several inches of water floating over the sand, but, on the contrary, the surface of the sand should be exposed to the air, the water only flowing on to it as fast as it passes through; and, secondly, the water should not be allowed to collect under the sand, but be drawn off nearly as fast as it filters; by this means the foundation of the filter is kept full of air, and, after passing through the sand, the water gets a subsequent purification in trickling over the pebbles and boulders below. If the water is not good after this treatment it must be bad indeed, and the lime treatment should be tried.

Purification of Water by Lime.—Lime has been used for a long time to purify water; and, though it was patented a few years ago, by Mr. Clarke, it was practised long previously, sometimes by throwing lumps of lime into the pits or lodges, sometimes by slacking the lime in a tub, and throwing it in, as milk of lime, with a scope, but it is probable that Mr. Clarke may have been the first to apply it to water for domestic purposes. The action of lime upon water is two-fold; in the first place, water which contains the bi-carbonate of lime is deprived of this substance by the addition of lime, for though it may seem paradoxical that lime should throw out lime, it is nevertheless quite true, and easily proved, that water contains less lime after the addition of a proper quantity of lime than previously, that is, after settling and filtration; the lime added combines with the lime in the water, and both together fall down as a sediment. The second action of lime is to throw out vegetable matters, and whether it accomplishes this by combining with them itself and carrying them down, or whether it is that the bi-carbonate of lime in the water keeps them in solution, and upon its being destroyed they fall out, or whether the action is made up of both these is not clearly known, but it is a fact that lime tends to diminish the quantity of organic or vegetable matter in water. There need be little fear of applying an excess of lime, or, at any rate, of that excess doing any harm. It is not possible to say what the quantity is that should be used, circumstances varying so much, but the author has known seven hundred pounds weight of quick lime applied, in ten hours, to about three hundred thousand gallons of water, and with good effect, but as a daily addition one quarter of this quantity should suffice. The lime should be added to the water in such a state as to ensure its utmost action, and in such a manner that it may be thoroughly mixed, therefore it should not be thrown in in lumps, but carefully slacked, and mixed

into a kind of cream with water. If practicable, it should be added to the water as it runs in the channel from the source to the first reservoir, letting the milk of lime flow from a tub into the water in a regular small stream, then, both running together, they will be well mixed, and the lime exercise its full action. The lime should be allowed time to perform its duty, and space enough to settle in before arriving at the filter, or else it will be troublesome, by choking the filter. As before remarked, it is hardly possible for an injurious excess of lime to be added, or to pass through the filter, the air removing an excess very quickly, but if an excess is suspected, it can be tested by red litmus paper, which is turned blue by lime water, or better, by adding a drop of solution of nitrate of silver to a wineglassfull of it, when, if it gives a brown precipitate, an excess of lime may be considered as present. Lime should not be used excepting the ordinary means of purification have failed. The great point is to imitate nature, as far as possible, in her method of purifying water, and that is exposing it to the air. The deep and silently flowing rivers are never so brilliant and pure as the shallow stream which runs amongst large boulders, over gravel and sand, the waters of which are continually broken into sheets, and thrown up into contact with the air. The power of the atmosphere, and a physical agent like sand, to remove substances from water is but little understood or appreciated ; it is far greater than most persons conceive, rendering bodies insoluble and inert which are little suspected of being acted upon by it ; it is, on a large scale, what animal black is in the laboratory, or even that more powerful agent, platinum black, the properties of which all students of chemistry are acquainted with.

Other Methods of Purifying Water.—Several methods of purifying water have been patented within these few years, but none of them have been applied on a sufficiently extensive scale to enable us to see if they are real improvements. The only real improvement that seems possible to be introduced, will be some apparatus that shall purify and filter large quantities of water in a small space. At present, the filters and water-lodges take up a good deal of ground, which could be otherwise employed if any such apparatus was to be introduced. There is not much inducement to spend money or time in such a matter as far as regards dyeing, bleaching, &c. ; because the works are usually in places where land is cheap, and the present method of filtering requires very little attention and expense to keep it in action ; but a compact and efficacious filtering apparatus would doubtless be a valuable property, and sooner or later be adopted by all who use large quantities of water.

Solvent Powers of Water.—Water is a physical rather than a chemical agent in bleaching and dyeing; it is the vehicle which carries the chemical substance to the cloth to be operated upon, or which removes the matters necessary to be removed from it. When a substance is mixed with water, it may either be dissolved by it, and disappear, as salt does; or it may remain in suspension, as chalk does. Nothing is considered to be actually dissolved in water if it can settle out again, or if it will not pass with the water through a filter made of paper or calico; thus, to talk of dissolving ground chalk in water is incorrect, for if allowed to stand it would settle out; or, if the mixture were filtered, the water would pass clear while the chalk would remain upon the calico: but blue vitriol (sulphate of copper), for example, does really dissolve in water, and the liquor all filters through together: to deprive the water of the blue vitriol would require chemical means different in kind from filtration. Water, therefore, dissolves some substances and not others. Water does not dissolve the same quantity of all soluble substances; of some it can dissolve its own weight, and more; of others, a smaller portion; and of some, extremely little. As a rule, hot water dissolves more than cold, and more quickly than cold; but, upon cooling, the excess mostly falls out as crystals. This point deserves notice, for a liquor, which is of right strength when a little warm, may be too weak when it becomes cold; left in a carboy, for example, in a cold place, because the salt crystallises out: this is the case only with those salts that are but sparingly soluble, as chlorate of potash, cream of tartar, sulphate of potash, &c. This crystallising is sometimes troublesome in steam colours which, right enough when freshly made, become filled with small crystals on cooling, and work rough in the machine: it is felt in the case of an ageing liquor, which contains chlorate of potash, as an active agent, which, crystallising out, leaves the liquor weak and not able to do its work. As an usual thing, the drug-room upon a printing or dyeing works should be cool, but there are some liquors better in a moderately warm place; brown vitriol, for example, in winter time is apt to go solid in the carboys, if kept in an exposed place. In the following table will be found most of the substances used in bleaching, dyeing, and calico printing, with useful information as to how they behave themselves with water: the results are from the author's experiments, and exact enough for practical purposes. The second column gives, in comparative expressions, the degree of solubility of the substance; the third, gives the degree of Twaddle which 16oz. of the substance dissolved in a gallon of water stands at; and, in the fourth column, are remarks proper

to the particular substance. By this table one can calculate, in a rough practical kind of way, how much of a salt there is in a gallon of water by knowing its strength; and, on the other hand, can tell how much of a drug to use to make a liquor at a certain given strength:—

TABLE SHOWING THE ACTION OF WATER UPON VARIOUS BODIES, AND STRENGTHS OF SOLUTIONS OF SOME OF THEM.

SUBSTANCE.	ACTION OF WATER.	STRENGTH OF A SOL. AT 160Z. PER GL.		GENERAL REMARKS.
		Tw.	Sp. Gr.	
Acid, arsenious	little sol.	..		Some varieties dissolve easier than [others.
„ citric	very sol.	6 $\frac{3}{4}$	1034	
„ oxalic	soluble	6	1031	
„ tartaric	very sol.	10 $\frac{1}{2}$	1052	Saturated solution.
Alum (potash)	soluble	10	1050	Nearly saturated in the cold.
Alum (ammonia)	soluble	10	1050	
Alumina, sulphate	very sol.	10	1050	
Albumen	very sol.	..		Coagulated by hot water.
Ammonia, muriate	very sol.	5 $\frac{1}{2}$	1027	
„ carb.	very sol.	8 $\frac{1}{2}$	1042	
„ sulph.	very sol.	10 $\frac{1}{2}$	1052	Mineral white, heavy spar.
„ oxalate	soluble	7	1035	
„ nitrate	very sol.	8	1040	
„ tartrate	soluble	9 $\frac{1}{2}$	1047	Does not dis. clear, always a sed.
Barium, chloride	very sol.	13 $\frac{1}{2}$	1067	
Baryta, nitrate	soluble	12	1060	
Baryta, sulphate	insoluble	..		Some kinds do not dis. without [acid.
Bleaching powder	soluble	11	1055	
Copper, acetate	soluble	..	.....	
„ chloride	very sol.	12	1060	Mostly sold as a liquid.
„ nitrate	very sol.	10	1050	
„ sulphate	soluble	11	1055	
<i>Dyewoods and Stuffs:</i>				
Archil	soluble	..		Sold as a liquid.
Alkanet	insoluble	..		Dis. in turpentine, spirits, oils.
Annatto	insoluble	..		Dissolves in alkali, soda.
Berries	soluble	..		Colouring matter very sol.
Catechu	soluble	..		Dis. completely in water.
Cudbear	soluble	..		Of these colouring matters not one dissolves completely in water. Water only extracts certain soluble principles, including the actual colouring matter, and leaves undissolved the great bulk, which is fibrous and woody matter.
Camwood	soluble	..	.....	
Cochineal	soluble	..	.....	
Fustic	soluble	..	.....	
Litmus	soluble	..	.....	
Logwood	soluble	..	.....	
Quercitron bark	soluble	..	.....	
Peachwood	soluble	..	.....	
Gall nuts	soluble	..	.....	
Madder	soluble	..	.....	
Sapan wood	soluble	..		Soluble in boiling water.
Sumach	soluble	..	.....	
Farina	insoluble	..	.....	
Flour	partly sol.	..	.....	
Glue	soluble	..		Some kinds thick, and some thin, [at 1lb. per gal.
Gums (foreign)	soluble	..	.....	

SUBSTANCE.	ACTION OF WATER.	STRENGTH OF A SOL. AT 16oz. PER GL.		GENERAL REMARKS.
		Tw.	Sp. Gr.	
Gums (British)	sol. & insol.	..	.....	Depends upon method of manuf.
Iron, acetate	soluble	..	.....	Sold as liq. at from 24° to 28° T.
„ muriate	very sol.	..	.....	Sold as a liquor, at 80° Tw.
„ nitrate	very sol.	..	.....	Sold as a liquor, at 90° Tw.
„ sulphate	very sol.	10	1050	
Lead, acetate	very sol.	12	1060	Gives a milky solution with com-
„ nitrate	very sol.	17	1084	[mon water.
„ sulphate	insoluble	..	.....	Dis. in some saline solutions.
„ red	insoluble	..	.....	Partly dissolved by nitric acid.
„ litharge	insoluble	..	.....	Easily dissolved by nitric acid.
Lime, quick	little sol.	..	.....	Lime water contains very little
„ muriate	very sol.	10½	1052	[lime.
„ carbonate	insoluble	..	.....	Ground chalk; dis. in acids.
„ sulphate	very lit sol.	..	.....	One part dis. by 400 parts water.
„ acetate	soluble	..	.....	Mostly sold in solution.
Magnesia, sulphate	very sol.	10	1050	
Manganese, acetate	very sol.	..	.....	Sold in the liquid state.
„ muriate	soluble	13	1064	Sold in the liquid state.
„ sulphate ..	soluble	..	.....	
„ blk. oxide ..	insoluble	..	.....	Not dissolved by cold acids.
Mercury, metallic	insoluble	..	.....	Dissolved by acids.
Mercury, bi-chloride	little sol.	17	1085	Quite saturated at 1lb. per gal-
Murexide	soluble	..	.....	[lon.
Potash, hydrate	very sol.	15½	1077	
„ carbonate	very sol.	13½	1067	
„ bi-chromate	soluble	13½	1068	Solution nearly saturated.
„ yel. chromate ..	very sol.	15	1075	
„ bi-tartrate	little sol.	..	.....	Cannot be made stronger than
„ chlorate	little sol.	6	1031	[about two degrees.
„ nitrate	very sol.	11½	1057	Very soluble in hot water.
„ red prussiate	very sol.	10	1051	
„ yel. prussiate ..	soluble	11	1055	
„ sulphate	little sol.	..	.....	Water does not dissolve one-
„ bi-sulphate	very sol.	13	1065	[tenth its weight.
„ oxalate	little sol.	..	.....	Saturated, marks 2½° Twaddle.
„ iodide	very sol.	14½	1072	
„ arseniate	very sol.	12	1060	
Soda, ash	very sol.	..	.....	Varies in its composition.
„ crystals	very sol.	7	1035	
„ bi-carbonate	soluble	13	1065	
„ borate	soluble	9	1045	
„ muriate	very sol.	13	1065	
„ nitrate	soluble	13	1064	
„ sulphate	soluble	10	1040	
„ stannate	soluble	12	1061	Varies according to its composi-
„ tungstate	soluble	15½	1077	[tion.
„ hypo-sulphite	very sol.	10	1050	
„ sulphite	very sol.	9	1046	
„ phosphate	soluble	6½	1032	
Tin crystals	very sol.	12	1060	Decomposed by much water.
Uranium, nitrate	very sol.	13	1065	
Zinc, acetate	very sol.	..	.....	
„ chloride	very sol.	15½	1077	Sold generally as a liquid.
„ sulph	very sol.	11	1055	
„ oxide	insoluble	..	.....	Dissolved by acids.

ICE—STEAM—INCRUSTATIONS.

When heat is withdrawn from water it becomes ice ; when heat is added it becomes steam. The freezing of water is attended by considerable increase in bulk at the very moment of congelation, which is the cause of the rupture of pipes and vessels containing it. The surprising power of freezing water can only be explained by admitting the expansion to be of a percussive and instantaneous nature. Steam has no chemical properties applicable to dyeing, it is a subject belonging more to mechanics than chemistry ; some references to it are contained in the chapter on Air. Incrustations are the result of the accumulation of the mineral constituents of the water used in boilers, and their composition depends upon that of the water used. There are many methods proposed for preventing the formation of these deposits, but their success is only partial. The chief attention should be directed to cause the deposit to assume a soft form which can be easily removed by blowing off, instead of the hard stony concretions which are so injurious. Among the matters recommended for this purpose are sawdust, potato peelings, a species of plumbago-looking ore, which is an oxide of iron, cream of tartar, muriate of ammonia, catechu, &c., &c.

COMPOSITION AND ANALYSIS OF WATER.

Water is composed, by weight, of eight parts of oxygen and one part hydrogen ; by volume, two of hydrogen and one of oxygen, which, by combination, are condensed into two volumes of steam. Hydrogen and oxygen combine only through some external influence, as heat, electricity, or the peculiar power of platinum, and one or two other substances ; the result of the combination is always water.

Water is the great medium in which chemical operations are carried on ; by putting the particles of matter into close contact with each other they are enabled to form combinations according to their natural affinities. There are many substances not soluble in water ; the great majority of saline compounds are, however, more or less soluble in it ; of those which are soluble in water a few divisions may be made respecting the manner in which they dissolve.

(1) Salts dissolving in greater quantity in hot than in cold water.

These include perhaps ninety-nine per cent of all soluble salts.

- (2) Salts dissolving equally well in cold as in hot water, and in equal quantity. There must be very few of this class, only the chloride of sodium is clearly shown to be so situated.
- (3) Salts dissolving more largely in cold than hot water. These are very rare, lime has been mentioned, the citrate of lime, butyrate of lime, and one or two others are known.

The quantity of salt dissolved by a given quantity of water varies for each salt; the relation of the solubility in hot and cold water is likewise various. Some salts increase in solubility regularly with the increase in temperature, others have eccentric curves increasing greatly towards the boiling point, while some, on the other hand, decrease in their ratio; one salt, at least, the sulphate of soda, appears to have a temperature of maximum solubility at about 100° F. and to deposit salt when the temperature is carried beyond that point. As a rule, the solution deposits upon cooling all the salt which it took up by the increase of temperature, leaving only so much in solution as would have been dissolved at the temperature to which it has cooled. Water is neutral in its behaviour to most salts, so that they are the same when the water has been driven away as before they were dissolved in it; some salts are decomposed by water, chloride of antimony and nitrate of bismuth for example; in the first case water appears to be decomposed thus: $\text{Sb}_2\text{Cl}_3 + 3\text{HO} = \text{Sb}_2\text{O}_3 + 3\text{ClH}$; in the second case there seems to be only a splitting up of the salt into an acid nitrate and a basic nitrate or oxide. The density of a solution of any salt in water is hardly ever the same as the arithmetical mean, in the vast majority of cases it is in excess of the mean, owing to condensation; in one or two cases it is the mean, there being no condensation, as in chloride of ammonium; in some other cases the addition of the salt to the water gives it an increase of density equal to the weight of salt, the salt occupying no space, such is the dry carbonate of soda, sulphate of copper, and a few others.

Water forms chemical combinations. There is water of crystallisation in most salts, this can be driven off at a moderate heat; there is also water of constitution, which either cannot be driven off or requires a very high temperature. The water in crystallised salts is constant in its quantity, and although the same saline compound can sometimes crystallise with various equivalents of water, it usually happens that the number of equivalents of water is constant for the same salt; in chemical formula the water of crystallisation is sometimes written as HO , with the number of equivalents prefixed, sometimes Aq. contraction of Aqua,

but this latter is mostly employed to express an indeterminate quantity of water.

Testing and Analysis of Water.—Only an outline of the tests and method of analysing water can be given here, for fuller information recourse must be had to the proper chemical treatises.

Test for Hardness of Water.—The soap test for ascertaining the hardness of water is a tincture of the best curd soap, made by dissolving one part of it in 75 parts of warm distilled water, and then adding an equal volume of rectified alcohol. This strength of soap tincture is not the only one which can be used, but it is convenient; it does not gelatinise at ordinary temperatures, which it would do if made stronger or without alcohol; it keeps well if there be no acid in the alcohol. On account of the variable quality of the soap the precise quantity of lime required to curd it must be ascertained by experiment. Take five grains of marble in a capacious porcelain dish, and dissolve it in pure hydrochloric acid, heat to expel the excess of acid, and then add forty ounces of distilled water, this produces an artificial calcareous water representing in its action upon the soap twenty grains of carbonate of lime per gallon of water; it should be again mixed with one or two volumes of distilled water, because the action of the test is not clear in waters containing an excessive amount of lime. On this account it is often advisable to mix a natural water to be tested with an equal volume of pure water. The water to be tested should be put in a phial, which it should not fill more than a third, and the soap tincture added slowly from a graduated measure, with occasional stoppages for the purpose of violently shaking the mixture; as soon as the soap bubbles remain permanent on the surface of the water the operation is finished. Of a hard water five hundred grains is sufficient to take at once, mixed with an equal volume of distilled water; of a less hard sample, a thousand grains may be taken without admixture.

A soap tincture made from a good specimen of white curd soap, gave the following results in the author's hands, which may serve for comparison with those obtained from any other good soap. The quantity of water used in each case was one thousand grains, and the numbers indicate the measures of soap tincture required to produce a permanent froth or lather, each measure equalling 10 grains water :

Distilled water	2 to 3
River water, Cheshire	8
Corporation supply to Manchester.....	9
River near Manchester.....	16

Water from the Thames.....	30
A spring water in Manchester.....	56
Same water after being treated with lime and filtered.....	32
Mixed spring and drainage water, neighbourhood of Manchester.....	34
The same after treatment with lime.....	17
A spring water from a dye works near Manchester.....	35
Water containing chloride of calcium, equal to 16 grains carb. lime per gallon.....	26

Water which will not froth with less than thirty measures of a soap tincture is not well suited for general dyeing purposes. I would not recommend a dependence upon this test altogether, and especially independent and separate observations are not of much value; it is only useful as a comparative test, and as before stated, indicates not only lime salts, but all other salts of oxides which form insoluble soaps with fatty matters.

The tests which may be applied to water, to form an idea of its composition, are as follows:—

Oxalate of Ammonia.—A white precipitate, indicates lime.

Nitrate of Silver.—A white precipitate, not dissolved by pure nitric acid, indicates chlorides.

Nitrate of Baryta.—A white precipitate, not dissolved by pure nitric acid, indicates sulphates.

Lime Water.—A white precipitate, indicates carbonates.

Phosphate of Soda, with addition of Ammonia.—Produces a white crystalline precipitate if magnesia be present. Before testing for magnesia the lime should be all removed.

Yellow Prussiate of Potash.—A blue precipitate, indicates iron.

Logwood Solution.—A dark purplish black, indicates iron; a deep claret indicates carbonated alkalies, or earths in solution.

It may be useful for the colorist to know how to make a quantitative determination of the chief constituents of a sample of water. The first step after having qualitatively examined the water, is to evaporate a known quantity, say ten thousand grains, to dryness by a gentle heat not exceeding 230° or 240° F. at the end; the residue weighed gives the gross amount of substances present in the water; the residue should then be raised to a low red heat, and the loss estimated as organic matter: it is possible that both carbonic and hydro-chloric acids may be lost in this way, but not often. The amount of lime may be ascertained by precipitating a pint of the water with oxalate of ammonia, adding

previously some chloride of ammonium to prevent the precipitation of magnesia. The magnesia can be estimated from the filtrate of the last operation by evaporating to dryness, expelling the ammoniacal salts, and re-dissolving with a little acid and precipitating by phosphate of soda and ammonia. The amount of sulphuric acid and of chlorine can in like manner be ascertained by precipitating a pint of the water with nitrate of silver and chloride of barium. The alkalies, iron, silica, and other substances, if present, are best determined in the residue left upon evaporation. For more minute instructions see the elementary works on chemistry. A complete analysis of water is a tedious and lengthy operation, only to be undertaken by a regular chemist; but it is possible to ascertain the above main constituents of a water in a comparatively short time, without requiring all the appliances of a complete laboratory. I append the analysis of some waters used by dyers and printers in Manchester and the neighbourhood, with observations upon them :—

ANALYSIS OF THE WATER OF THE TAME AT TWO POINTS.

	<i>Above Stalybridge.</i>	<i>Below Stalybridge.</i>
Sulphate of lime.....	1.399	2.210
Carbonate of lime	0.584	1.421
Chloride, sulphate, and carbonate magnesia	1.691	2.949
Silicic acid.....	0.260	0.600
Oxide of iron.....	0.340	0.240
Organic matters.....	0.960	1.100
Alkalies, KO and NaO ...	traces	0.720
Ammoniacal salts.....	.....	0.650
Grains per imp. gallon...	5.234	9.890

Both these waters were good for calico printing and madder dyeing purposes. The analysis was made in the spring of 1853; other analyses of the same water show that it varies in composition at different times of the year. The water below the populous town of Stalybridge has become nearly a hundred per cent more impure than it was two miles above it: the existence of increased amounts of the alkalies and ammonia show the nature of the added impurity. Ten grains of salts in a gallon of water is not an excessive quantity.

I give here the analysis of two samples of spring water pumped from

a print works doing first class madder styles. They are remarkable for their ferruginous nature :—

	No. 1 Pump.	No. 2 Pump.
	GRAINS.	GRAINS.
Iron calc. as Fe_2O_3	4.24	2.10
Sulphate of lime.....	3.30	3.62
Carbonate of lime.....	3.77	3.50
Chlorides of potassium and sodium	1.50	0.73
Magnesian salts.....	0.60	Mg. Cl. ... 1.52
Sulphate of soda.....	2.34	1.23
Silicic acid.....	0.30	0.48
Organic matters.....	trace	trace
Per imperial gallon	16.05	13.18

These waters were perfectly clear when drawn, but soon became turbid, depositing flakes of peroxide of iron. The iron was speedily eliminated at the filters, so that the filtered water contained only a trace in combination with some organic matter. Madder work dyed in this water freshly drawn had the whites tinged, and all the other colours greatly deteriorated. It is possible that if this was the only source of water, the works could not have been carried on, because the great quantity required would not have allowed of the deliberate filtration necessary to throw out all the iron ; but it was mixed with a better quality of water and the water which had been used in washing the madder work, and still containing some of the soluble matters of the dye ; these precipitated the iron quickly, and the two were thus reciprocally purified, the one from its mineral, the other from its organic matter. I analysed a sample of water from the centre of the city, which was excessively charged with mineral matters. I append the result of the analysis as illustrating a water bad for dyeing purposes :—

Sulphate of lime.....	37.4
Chloride of calcium.....	14.3
Carbonate of lime.....	5.92
Chloride of magnesium.....	31.66
Carbonate of magnesia.....	3.19
Chloride of potassium	1.32

93.79 grains per imperial gallon,
besides traces of soda, silicic acid, and nitric acid.

THE ELEMENTARY CONSTITUENTS OF WATER—OXYGEN AND HYDROGEN.

Oxygen is a gas, colourless, tasteless, odourless, supports combustion ; it is not a natural product, but always made by art. It has not received any application in the arts of dyeing and printing : it is used in the oxyhydrogen blowpipe, and seems likely to come into use for the fusion of the more refractory metals.

Small quantities are most conveniently prepared from chlorate of potash, larger quantities more economically from mixtures of bi-chromate of potash and sulphuric acid ; but the cheapest source is a good quality of peroxide of manganese. Deville and Debray state that from eight to nine per cent of the weight of the manganese may be obtained. Boussingault has proposed to extract oxygen from the atmosphere by means of the oxide of barium, which, under favourable circumstances, absorbs an atom of oxygen, and can by a current of steam be decomposed into baryta and free oxygen. This process, from its description, seems the best, but I am not aware that it has been put into use, probably owing to some practical difficulties.

Oxygen possesses active and powerful affinities which are assisted by heat. It combines with the metals, depriving them of all their metallic properties, making them into powders of an earthy appearance : these are *oxides*. It combines with the non-metals, producing acids. It is a producer and destroyer of colour. It changes indigo-white into blue, and indigo blue it destroys, changing it into some colourless substance. The most powerful actions of oxygen do not take place with the pure gas ; it is in the *status nascendi*, the nascent state, the moment of its being liberated from its compounds, it exerts its most remarkable oxidising actions. Such is the case of bleaching or discharging with acids and bi-chromate of potash, with alkalies and the red prussiate, with the peroxide of lead and other matters. Either the gas is in some physically different state at the moment of its liberation, or it has a chemical activity unknown to its free state ; the latter seems most probable from the discovery of the body called Ozone.

Ozone is the name given to a body whose actual existence and composition remain in question. It is perhaps a molecular modification of oxygen, it is not quite certain whether it contains hydrogen or not. Air and oxygen can be ozonised by electricity or by phosphorus, and the oxygen is then found to have an amount of chemical activity which it never possesses alone ; it bleaches, it liberates iodine from iodide of potassium, oxidises sulphurous into sulphuric acid, and performs other

oxidising actions all consistent with the supposition that it is pure oxygen, but with the certainty that it is in a very different state from common oxygen gas.

The subject of ozone is highly interesting in a practical point of view, for if ever oxygen is to be applied to the performance of those reactions which are indirectly attributable to it, such as bleaching or elevating colours, it must be through the medium of this ozone or some similar body. Common oxygen is to ozonised oxygen what a rod of iron is to a sharp sword, both of the same substance but in different states of activity and of very different powers. There is reason to hope that if ever the oxygen of the air can be ozonised in a practical manner, chemists will be able to effect those oxidations directly, which are now accomplished in circuitous and expensive manners.

Oxygen, existing in the air, and being in fact the only active element in it, is the origin of most of the changes which take place in a spontaneous manner in nature. The gradual destruction and disappearance of organic matter can be all traced to the action of oxygen, the carbon is converted into carbonic acid, the hydrogen becomes water, and the nitrogen passes eventually into nitric acid. There is no element in nature with which oxygen cannot enter into combination, and so alter its appearance and properties to a most remarkable degree. Fluorine is said to be an exception, not forming a compound with oxygen, but too little is known of this element to justify the statement. The action of oxygen upon other matters is more or less energetic as the temperature is higher or lower; it seems probable that at sufficiently low temperatures it has no action, while at high temperatures it produces the most surprising effects. The fading of colours as well as bleaching, which is only a case of colour fading, may be attributable in most cases to the action of oxygen, light assisting; colours upon fabrics cannot be preserved from the action of oxygen in any way except that of covering them with a varnish. Vegetable colours remain good and bright for centuries, when protected with oil or varnish, while the same would fade in a short time if deposited as an ordinary dye.

HYDROGEN.

Hydrogen is the lightest of all known bodies, 100 cubic inches of it weighing only 2.137 grains; it is very suitable for balloon purposes, but the greater facility of obtaining coal gas causes that to be chiefly used, although not nearly so buoyant; a notable example that the theoretically fittest material is not always that which can be practically applied with

advantage. Hydrogen is a gas not yet brought to the liquid state, it is colourless, tasteless, and inodorous when pure, combustible but not supporting combustion, very little soluble in water. It has no applications in the arts of dyeing and printing.

It is this gas which is formed when iron turnings are put into spirits of salts to make muriate of iron, also when vitriol or spirits of salts are neutralised with zinc, iron, or tin; as it explodes by heat when mixed with the air, care should be taken to perform these operations in an open place, or in a good draught, keeping lights away from the vessel in which the operation is going on. Hydrogen gas has no smell when pure, but the gas which comes from the above operations is very noxious, principally because the boiling motion of the liquor throws up a cloud of excessively fine particles of the acid liquor which float about on the air for a long time; this can be in great measure prevented by stretching a wet sack over the mug or tub and keeping it wet; but when possible these operations should be performed in a draught.

It is always prepared from water, and there are many means of obtaining it, but those chiefly used are by decomposing the water by means of a metal; for example, potassium thrown into water decomposes it at once, attracting the oxygen and setting free the hydrogen; steam passed through red hot iron turnings is decomposed, the oxygen is absorbed by the iron and the hydrogen liberated; by using acids and metals the decomposition takes place at low temperatures, and the most convenient method of preparing hydrogen is to act upon water by means of zinc and sulphuric acid. There is a peculiarity about the decomposition of water by hot iron which is interesting itself, and full of suggestions to those engaged in the arts. Water passed over red hot iron is decomposed into hydrogen and oxygen, the latter becoming fixed with the iron; but hydrogen itself passed over the oxide of iron takes the oxygen and re-forms water and metallic iron. The degree of heat at which these changes take place is not sensibly different in one case than in the other; the cause of the opposite effects produced has to be sought for in the disturbance by other causes of the delicately balanced affinities of the various elements. An atmosphere of steam may permit or encourage the formation of hydrogen, and *vice versa* the atmosphere of hydrogen may induce the formation of steam; the presence of an excess of the unoxidised metal in the one case and of oxidised metal in the other may have opposite effects; it may be a decomposition varying according to the bulk or mass of either one or the other element; it is not certain what is the real cause, but it is an example of the apparently irreconcilable phenomena which often appear in dyeing. The deposition

of colours upon fabrics is the result of very delicate attractions, in most cases not well understood ; a process is followed with regard to two lots of pieces which appears to be perfectly identical, and yet very often the result is not the same. The workmen will assert, and probably honestly, that they have adhered to instructions, but if all were known there would be found some small and apparently unimportant point which has influenced the result to one side or the other, and which would only be apparent or suggest itself to the mind of one previously prepared to expect such actions.

Peroxide of Hydrogen, or Oxygenated Water.—This body, which contains twice as much oxygen as water, was first discovered by Thenard. Its properties are very curious and somewhat paradoxical, but several of them seem to hold out a promise of being applicable to the arts we are treating of, and on that account it deserves attention from the technological chemist. The method of its preparation is difficult, and requires many precautions, a full account of which may be seen in Gmelin's Handbook, 2 vol. (Eng. Tr.) and other similar works. Its active properties depend upon the facility with which it parts with the extra atom of oxygen which it contains, usually oxidising bodies placed in contact with it. It appears to be endowed with bleaching properties; it has been supposed, without much reason, however, that the bleaching properties of evening dew are owing to the presence of some of the peroxide of hydrogen. There is no doubt that if it could be produced at a tolerably cheap rate, it would serve some useful purposes in dyeing or bleaching. It has as yet been purely a laboratory product, but there is no reason why it might not be made upon a large scale, for when diluted and mixed with some salts, it appears to have a stability not less than that of several commercial articles, bleaching liquor for example.

CHAPTER III.

NITROGEN, AND ITS COMPOUNDS WITH OXYGEN AND HYDROGEN—THE
AIR—AGEING—HYGROMETERS—AMMONIA—NITRIC ACID AND OTHER
COMPOUNDS OF NITROGEN.

NITROGEN.

NITROGEN is a gas ; it forms the greater bulk of the air ; it has no applications in the arts, and is singularly devoid of active properties when isolated. In combination with other elements, it appears to communicate to them the most exalted properties ; the most powerful vegetable poisons, as well as those animal substances which appear to be the embodiment of vital principle, contain nitrogen, and if this element were removed from them, their composition would not differ from a host of neutral and indifferent substances.

THE ATMOSPHERE.

Air is a mixture of nitrogen and oxygen gases in the proportion of 79 parts of the first to 21 parts of the second. In round numbers oxygen may be said to form one-fifth part of the air, and nitrogen four-fifths ; besides these two gases, there are two or three other bodies present in the air, though in very small quantities. A minute analysis of ten thousand parts of dry air stands as follows :—

Nitrogen	7912
Oxygen.....	2080
Carburetted hydrogen.....	4
Carbonic acid.....	4
Ammonia.....	traces
	10000

But air is never naturally quite dry, vapour of water being always present, the quantity of which is, however, very variable, depending upon circumstances treated of further on. It is oxygen gas which is the active principle of air; the nitrogen seems to be quite inert, having no action upon animals, plants, or minerals. The only use that can at present be attributed to it is, that mixing with the oxygen, it dilutes it and prevents what would probably be the too energetic action of the vital element. An account of the chemical action of air is therefore mainly in reference to the oxygen it contains. Air has usually an oxidising action upon other matters, that is, the majority of substances have a desire to take oxygen, and under favourable circumstances, do take it from the air, and become altered in their appearance and properties by it. A familiar case is the rusting of iron. Iron is a pure metallic element, but it does not naturally exist as such; like most of the metals, it is procured by art from an earthy ore, which is a combination of the metal with oxygen and some other of the elements: the pure metal is disposed to return to its earthy oxidised state when it can obtain oxygen; this it does readily from damp air. It rusts or oxidises, and in time the rust would penetrate through the iron, not leaving a particle of metal. Lead, tin, zinc, and most metals, are oxidised in the air, but the oxygen does not penetrate them as in the case of iron, because the oxide formed is of a tenacious nature, adheres to the metal, and so protects it from further action; freshly cut lead is as bright as silver, and would remain so if it were not for the oxygen in the air tarnishing it almost instantly with a coating of oxide of lead. In speaking of the purification of water, allusion is frequently made to the action of the air. It is the oxygen of the air only which acts, and it is by the impurities absorbing this oxygen that they become removed from the water. The air plays a very important part in bleaching, dyeing, and calico printing, and under those separate heads its special action in various circumstances will be treated upon.

Influence of Air in Bleaching.—The atmosphere was formerly the only bleaching agent, but since the application of chlorine and its compounds it has little to do. It is well known that all calico and linen was bleached until the end of the last century by exposure on the grass; even yet much linen is bleached in this way, and in less civilised countries it is the only method of bleaching known. Reserving details upon bleaching, it may be stated now that the end and final action of oxygen upon colouring matters is to convert them into a yellowish or brownish substance, possessing some of the characters of what chemists call extractive matter; it is partly soluble in water, but more easily

dissolved by soapy and alkaline liquors. The old method of bleaching was nothing but a succession of washings and oxidisings. But as the natural colouring matter of cotton and linen, or the dirt acquired in its manufacture, is not very readily acted upon by the air, it required reiterated and prolonged exposure to effect the bleaching, and from six weeks to three months might elapse between the arrival and departure of the goods from a bleachworks. The colouring matter was thought to be a good deal acted upon by the dew, and some chemists have considered that it contained the oxygenised form of water referred to in Chap. 2, which is known to be a powerful bleaching agent, but this assumption is quite unproved, and as it is also unnecessary it may be dismissed. It does not seem probable that dew exerts any other action than pure water does, and as it is quite certain that very little bleaching action would take place unless the cloth was kept in a damp or moist state, the impression that dew was particularly active may have arisen from noticing that the bleaching was sooner effected when the nights were dewy than otherwise, but it will be more correct to attribute the difference of action to the cloth being kept moist all the night than to any chemical activity in the dew itself. In the modern process of bleaching cotton fabrics the air takes very little part, probably none at all, but if it acts anywhere it is while the goods are lying in the chemic (bleaching powder) steep, and here it acts more through the carbonic acid it contains than through its oxygen, and this action is quite insignificant.

Influence of Air in Dyeing.—It has been stated that the ultimate action of oxygen is to destroy colours, but there is an intermediate state in almost every colour where oxygen elevates and brightens it, so that, as a general rule, goods which are being dyed should be regularly exposed to the air. This is always done in practice, more because the evenness of the dye necessitates a constant motion of the goods than from any recognition of the usefulness of the air in dyeing. It is oxygen which in some cases makes all the difference between no colour and a good colour. In manganese browns and iron buffs, as the colour is first developed it is poor and valueless, but by a proper exposure to the air, or to some chemical oxidising agent, full and fast buffs and browns are produced; an atom of oxygen makes the white oxide of lead into a deep puce, and less than an atom of oxygen makes it the bright red of red lead. The colouring matters of archil, litmus, and indigo are white, and only attain their full and well known shades by absorbing oxygen. Indigo is a striking example, familiar to all who have worked with it. In giving a light ground or skying with the indigo vat, the cloth rises out white or yellow; by the time it has been raised a yard it becomes decidedly

greenish, and its tone deepens more and more until it becomes quite blue, when it has been exposed from three to seven minutes to the air. This is a case of absorption of oxygen, and though it is not so apparent in other dyes, it acts in a greater or less degree. In Turkey red dyeing a considerable exposure is required to oxidise the fatty matters which act as a mordant. Logwood, madder, and some other dyestuffs, are thought to be improved by being turned over in a moist state, and it is a general opinion that dyewoods are improved by age, which is almost always another way of expressing an oxidising influence.

Influence of Air in Calico Printing.—It has been stated that air contains vapour of water; it is diffused through it in an invisible form, and is present in variable quantities. Probably this water in the air is its most important constituent as far as concerns calico printing, for it can be shown that when the air acts upon any substance by its oxygen, it is principally through the medium of the aqueous vapour that the action takes place, and in the majority of cases it is the aqueous vapour only which is active. The climate of England, and more particularly that of the north-western coast, is notably moist; rain is frequent, and the atmosphere, in the finest weather, contains large quantities of watery vapours. This circumstance is very favourable to calico printing in many ways, and gives the manufacturer great advantages over those who are not so well situated. In many foreign climates the air is naturally so dry that the printer is harassed with difficulties, and driven to appliances unknown in our moister climate, and it frequently happens that the utmost care and skill are insufficient to cope with the disadvantageous circumstances, and the manufacturer is obliged to abandon the more delicate styles of work, or be content with producing them very inferior in quality. The aqueous vapour in the air is attracted and condensed by many substances, especially those of a porous nature. If a portion of calico be thoroughly dried before a fire until it loses no more weight, and then be hung up in the air, it will attract the moisture of the air into its pores, and increase in weight as much as ten per cent, more or less, depending upon the condition of the atmosphere; in this state it will appear dry to an ordinary observer, but one used to handling calico in different states knows that it is moist, and possessed of different properties to quite dry calico; it is more flexible, less elastic, and inclined to retain any particular form it may be pressed into, and as a consequence taking better impressions from engraved rollers. In copper-plate printing the thick paper must be quite damp to take a good impression, and so in calico printing the calico must be somewhat moist to get the best result from the engraved

rollers ; this is more observable in fine outlines, stripes, and pin work, than in opener, heavy, or blotch work ; but even here a marked difference in the result is discernible. This is one influence of the air, and a very important one, the damping of the white piece before printing ; it requires very little care or trouble, as before said, to bring the cloth to this condition in our climate ; it only requires to be kept a few days, or a few hours, in a cool room—and the white room of a print works should always be a cool, moist place for this purpose. In France and America artificial means of moistening the cloth are occasionally used, but never with as good results as the natural moistening effected by a humid air, and on this account English manufacturers have a special advantage in certain styles of work.

The next important action of the air is in the “ageing” of the printed pieces. When the piece leaves the drying chests or cylinders, it is almost quite dry ; it has lost not only the water in the colour printed on, but also its natural hygroscopic or attached water. It is then, for most colours, hung up in the stove or ageing room for a certain length of time : this may be for two reasons, either the cloth may have to be printed again, as in some madder styles, which are two or three times printed, and then it is found that a few hours or a night's age softens the cloth, and it prints better, or the first printing is all that it will receive, and it is hung up for some time before dyeing to undergo what is called ageing. What is it that takes place during ageing, and why is ageing necessary ? This question is full of interest and worthy of all the consideration we can bestow upon it. The older chemical writers upon dyeing and printing have stated that ageing was principally an oxidising process, and secondarily, a process for allowing the volatile acids of the mordants to escape from the cloth. Recent observations do not attribute so much importance to oxidation, but rather incline to look upon ageing as a process of soaking in of the mordant, a physical or mechanical rather than a chemical process. It can be proved that mordanted cloth ages as well in gases which have no oxygen as in pure oxygen itself ; an experiment which may be tried with hydrogen or coal gas. It is not meant to assert that oxygen takes no part in ageing, but that it fills only a subordinate part ; and if it was only this which was required, ageing could be dispensed with, and the oxidation effected more cheaply by chemical agents. Alumina, or red-liquor mordants, cannot absorb oxygen under any circumstances, and yet ageing is as necessary for them as for iron-liquor mordants, which are said to require oxidising. With regard to the oxidising of iron mordants, there are mistaken notions entertained by writers. It may be definitely stated that there is very

little oxidation of the iron mordant, even after a prolonged exposure to the air; that this oxidation is not necessary to the production of good colours; that no length of exposure would, or could, completely oxidise the iron; and that, if by any chemical process, the iron mordant is completely peroxidised, it is much injured, or entirely destroyed as a mordant. That portion of oxygen which iron mordants do absorb is absorbed quickly, almost instantaneously, during the passage of the piece across the drying chests, and in the washing after dunging. Chemists are well acquainted with the rapid chemical action which ensues upon minute division of substances; thus, metallic iron absorbs oxygen from the air, but it does so slowly, taking many weeks to rust through a thin plate; but the metal can be obtained by a chemical process, as a fine powder; and this absorbs oxygen so fast that it becomes spontaneously red hot, and in the course of a few minutes is completely oxidised. Somewhat similar is the effect of spreading a weak solution of iron over the millions of superficial inches which exist in the fibres of an ordinary piece of calico: not only does this immense surface expose the iron mordant to the action of the exterior air, but there is always a great deal of air in the fibres, probably in a more condensed state than common air, which yields up its oxygen to the extent that the mordant can absorb it. The tarry matters in iron liquor serve as a preventative of excessive oxidation; the gum, flour, or starch used as thickening has also the same action to a certain degree, and between the two it is quite impossible to convert the iron mordant even by a twelve month's ageing into that highest state of oxidation known as the peroxide of iron. Having thus disposed of the oxygenating effect of ageing, it is necessary to show in what ageing really consists, as far as observation and experiment can prove it. There is no question that ageing does enable the mordant to fix itself more abundantly and completely than would be the case without ageing, although in light shades the major part of the mordant is fixed as soon as it leaves the drying chests. But in dark shades a good deal of the mordant is fixed during ageing, and generally speaking the darker the shade, and the greater the quantity of colour upon the cloth, the longer the ageing required to give a good result. In the following explanation of the utility and phenomena of ageing it is assumed that the fibre of the cloth has a positive affinity for several metallic oxides, iron among the rest, and that it is a real chemically acting agent. It is an axiom in chemistry that action only takes place at infinitely small distances; that to induce combination between two bodies it is necessary that they should be brought into absolute contact with each other. To illustrate this by an experiment:

let bi-carbonate of soda in powder be mixed with tartaric acid also in fine powder; no visible action takes place, because, although the powders be as fine as they can be made, yet the distance between the particles is too great for them to exercise their natural attractions; but add water to the mixture, and immediately an effervescence ensues and the acid and the alkali mutually neutralise each other; the water simply brings the two substances into close contact. Just the same takes place in ageing, through the water which is contained in the air. Strong iron liquor contains about five per cent of the protoxide of iron, and strong red liquor not more than three or four per cent of alumina, these are mixed with five or six times their weight of other matters, and, when thickened with gum, &c., for printing, are in the presence of from ten to a hundred times their weight of neutral and obstructive matters—substances which interfere to prevent the fibre coming into close contact with the iron or alumina which forms the mordant—and so in proportion to the depth of the engraving or to the amount of colour put on the cloth, there is a quantity of mordant which does not come into actual contact with the fibre, and never would if it were washed off direct from the printing machine. But the moist air in the ageing room softens the colour, makes it spongy and elastic, brings it into such a state that the capillary action of the fibres commenced in the first contact can continue and draw up the mordant; a sluggish circulation goes on, more of the mordant is brought into actual contact with the fibre, the oxides of alumina and iron are attracted by it, the acetic acid is left at liberty and easily escapes through the softened colour, some oxygen is absorbed, and thus the process completed. The rapidity of ageing should, according to this, be in proportion to the humidity of the air, and so it is, with certain relations to the heat or temperature. It will probably be found that the processes described above are consecutive, that in the coolness of night the pieces become moist and capillary action goes on; in the day the pieces are dryer and the combination of the fibre and the mordant takes place and the acetic acid escapes. Ageing will take place more rapidly and effectually at one time than at another, warm days and clear cool nights seem to be the best for it; in dry easterly winds ageing does not go on satisfactorily, and at times sprinkling the floors with water, driving in steam, etc., have been had recourse to with various results, not always satisfactory. The author has not found a temperature of 32° F. or freezing, to stop the progress of ageing when pieces have been kept from exposure, that is in a building; probably although the air was so cold the cloth may not have fallen to that temperature. But, in a continuously cold winter, ageing does not pro-

ceed well, and sometimes print works are brought to a stand still from this cause alone. With regard to steam colours it does not appear that ageing does any good; it is perhaps the most general custom to hang the pieces, whether calicoes or delaines, for a night before steaming, but there is no necessity for it, some of the best work is done by taking the pieces straight from the machine to the steaming kennels or steaming tins, and then, after pulling them over, washing off directly. The steam, by its heat and moisture, brings the colours to nearly the same pasty state they were in before the piece was dry, the fibres easily absorb the colours, and this is all that is required. It will have been observed that the better kind of steam blues, those with tin pulp or prussiate of tin in, do not seem good directly after washing, looking bare and dull, but they become full and brilliant by a few hours hanging; this is a case of oxidation. Spirit colours require ageing in order to allow the tin, which is their principal ingredient, to combine with the fibre and the colouring matter employed; they must have a cool ageing on account of the very acid nature of the oxymuriate of tin. Catechu colours require a long ageing for dark shades, this is a case of almost pure oxidation effected by the air through the intervention of the ingredients of the colour, which serve as carriers of oxygen to the catechu.

Aluminate of potash, or alkaline pink mordant, requires but little, probably no ageing. It is stated that the carbonic acid of the air combines with the potash, and the alumina adheres to the fibre; the author is of opinion that such is not a correct explanation, and has no foundation in fact. Three days' exposure to a current of moist carbonic acid fixed no more alumina on a fent than the same time in air deprived of carbonic acid, which was a very trifling quantity indeed, and not due to carbonic acid at all; if the alkaline pink is any better for ageing, it is owing to the more perfect contact of the fibre and mordant which takes place than to any purely chemical action of the air.

Chemical Assistants in Ageing.—The length of time and the extensive space required in ageing, not to speak of the labour of putting up and taking down, so many pieces, the many accidents of drops, dirt, tearing, &c., that a three or four days' hanging always produces, have impelled many persons to seek some chemical substance which should fulfil the conditions required in ageing. The attempts have so far been only partially successful and are not generally made use of. Pieces were padded in solutions of various salts, the best of which is chlorate of potash; its expense operated against it, and it is only sparingly used. It has an injurious effect upon anything containing resist red,—that is, a red having crystals of tin or muriate of tin in its composition, with

the intention of throwing off or resisting light covers of purple or chocolate,—the colour does not resist, an effect which may be attributed to the salt acting upon the tin, oxidising it, and partly neutralising its acidity. One of the best preparations was a liquid consisting of a saturated solution of chlorate of potash, with the addition of arsenite of soda : this was to be added to the colours in the proportion of half a pint to a gallon, one night's age was sufficient ; it worked tolerably well, but not regularly, the shades were not to be depended upon, varying in intensity to a considerable and unaccountable degree. Some years ago, a French or German colorist announced that by the use of ammoniacal gas it was possible to have pieces ready for dyeing in a few minutes ; experience and further experiments have not confirmed this statement.

Ageing Boxes.—A good many years ago attempts were made to age pieces in an atmosphere heated by steam, and containing steam itself. It was a kind of a box through which the pieces passed, being exposed in their passage to the mixture of steam and air ; it was not successful, the results were irregular, and it was found impossible to prevent accidents from the condensation of the steam. More recently the experiment has been repeated, and with good promises of success ; there are yet some practical difficulties to be surmounted, but they do not seem insuperable, and it appears likely that in a short time every printworks will have its steam ageing box for occasional, if not for regular use.

It has been stated that the quantity of moisture in the air is variable. Warm air can hold more than cold, and both have their limits ; air can no more hold above a certain quantity of water, than water can dissolve above a certain quantity of a drug ; but it can have any quantity less until it comes to perfect dryness. A table is given here of the quantity of water held in a cubic yard of air of certain temperatures when the air is as full as possible of watery vapour.

TEMP.	WEIGHT IN GRS.	TEMP.	WEIGHT IN GRS.	TEMP.	WEIGHT IN GRS.
32°	60.1	95°	429.2	158°	1646.5
41	83.3	104	537.2	167	2012.0
50	117.2	113	679.5	176	2316.0
59	148.2	122	852.2	185	2625.0
68	193.6	131	1026.8	194	2910.0
77	255.6	140	1221.3	203	3171.7
86	330.3	149	1473.1	212	3417.2

Instruments, called hygrometers, are sold, which indicate the degree of dampness of the air ; the better class of instruments, and those only upon which reliance can be placed, are too delicate in their construction,

and require too much care in their application, to be used except by persons accustomed to handle philosophical instruments. There is, however, an instrument containing two thermometers, the mercury bulb of one of which is kept wet by a fountain of water, and the other dry, as usual; it is called from this the wet and dry bulb hygrometer, and can be used to give a rough idea of the degree of moisture of the air in any place. When the air is dry the wet bulb thermometer is much lower than the dry, the moister the air the nearer the wet bulb approaches in its indications to the dry bulb, and in a thoroughly damp air both the thermometers stand at the same point. The depression of temperature in the wet bulb is owing to the evaporation of the film of water covering it taking heat from the metal and glass. The rapidity of this evaporation is proportioned to the dryness of the air; in saturated air there is no evaporation, in quite dry air it is most active. The dry thermometer simply indicates the temperature of the air. To ascertain the exact quantity of moisture in a given bulk of air, by this means, requires a mathematical calculation, in which, besides the temperature indicated by the thermometers, account has to be taken of the pressure of the atmosphere, and the tension of the vapour of water corresponding to the temperature of the wet bulb. For full explanations see Glaisher's pamphlet on the dry and wet bulb hygrometer. Daniels' hygrometer and the modifications of it are more certain in their results than the wet and dry bulb thermometers, depending as they do upon the dew point or temperature to which the air must be lowered to become saturated with the moisture, but they are too delicate for ordinary use. The hygrometer is useful in enabling the manufacturer to obtain an atmosphere of constant dampness when necessary; such an atmosphere, being usually required warmer than the external air, can be obtained by the admission of steam, the quantity of which is regulated by the indications of the thermometers; when they are approaching too near the steam must be cut off, when the wet bulb is falling too low more steam must be admitted.

Nitric Acid (aqua fortis).—Nitric acid is a compound of nitrogen and oxygen, it is entirely a manufactured article, never being found free in nature; it is all obtained from either saltpetre, which is a nitrate of potash, or from nitrate of soda, the Chilian saltpetre. It is a strong acid, and possesses powerful oxidising properties. It is not used in bleaching, and very little in either dyeing or calico printing, but it is employed in considerable quantities by the manufacturing chemists who make drugs for dyers and printers. It is used for making nitrate of iron, nitrate of lead, oxymuriate of tin, and several of those solutions

of tin known as dyer's spirits; it is used for a few colours in calico printing, and sometimes to cut madder pinks, that is, to reduce the red to a softer shade. It is occasionally employed to give silk a fast yellow colour, by passing it through tolerably strong acid, and washing directly. It has the property of tinging all or most animal substances of a yellow colour; it is used for etching rollers and deepening engravings, and in several other trifling cases. The strength of nitric acid is usually determined by the hydrometer, which is a good enough test between honest people, but it is possible to make it seem strong by putting vitriol in, and one or two other substances. Commercial nitric acid is occasionally contaminated with large quantities of spirits of salts or muriatic acid. It is the most expensive of the acids used in large quantities, and there are inducements to mix cheaper acids or salts with it. The test for muriatic acid is nitrate of silver; for sulphuric acid, or vitriol, nitrate of baryta, diluting the aquafortis to be tested with pure water, so as to allow the tests to show properly. If any solid substance is present it is detected upon boiling down a little of the acid to dryness, in a proper vessel. If the acid be unadulterated its strength will be in proportion to the figure it stands at upon the Twaddle. The very strongest nitric acid that can be made contains some water, so that commercial nitric acid is a mixture of a certain quantity of real supposed dry nitric acid and water, and by consulting the following table the quantity of real acid in commercial aquafortis, of any given strength, can be ascertained. The table is adapted from Dr. Ure's determinations.

TABLE SHOWING THE QUANTITY OF ANHYDROUS NITRIC ACID IN ONE HUNDRED PARTS OF LIQUID ACID, AT VARIOUS DENSITIES.

TWAD.	DRY ACID IN 100 PARTS.	TWAD.	DRY ACID IN 100 PARTS.	TWAD.	DRY ACID IN 100 PARTS.	TWAD.	DRY ACID IN 100 PARTS.
100	79.70	65	44.50	46	31.20	28	19.90
96	73.32	62	42.20	44	30.00	26	18.50
92	68.54	60	40.60	42	28.80	24	17.20
88	64.50	58	39.10	40	27.60	22	15.90
84	59.77	56	37.80	38	26.40	20	14.40
80	56.58	54	36.60	36	25.00	15	11.00
76	52.60	52	35.10	34	23.90	10	7.50
72	49.41	50	34.00	32	22.50	5	3.50
68	47.00	48	32.60	30	21.40		

The best method of ascertaining the actual value of nitric acid is to determine the amount of other acids present, and deduct them from the gross acidity of the sample under examination. The hydro-chloric acid

is determined as chloride of silver, and the sulphuric acid as sulphate of baryta. The acidity of the whole may be tested by ascertaining how much pure carbonate of soda a given quantity can neutralise. Pure nitric acid for laboratory or special purposes is obtained by precipitating the hydro-chloric acid from ordinary acid by nitrate of silver, and then distilling. If there is no other impurity but hydro-chloric acid present, it may be expelled by keeping the acid at near its boiling point, on a sand bath, for several hours.

Bi-oxide of Nitrogen, called also Nitric Oxide, Nitrous Acid, and Deutoxide of Nitrogen—Formula NO_2 .—It is a gas, colourless, mixes with air or oxygen, and forms red or orange coloured vapours, such as are produced in making nitrate of iron, or several kinds of dyer's spirits. Its affinity for oxygen is very great; it is best prepared by acting upon nitric acid, with copper turnings; the copper withdraws oxygen from the nitric acid to form nitrate of oxide of copper, and the gas is evolved. The reaction may be expressed as follows: $3 \text{Cu} + 4 \text{NO}_3 = 3 \text{CuO} + \text{NO}_2$.

No applications; but is, I think, capable of receiving some. It is a carrier of oxygen, and may perhaps be usefully employed as such; it is not applicable as an oxidiser for colours on account of the formation of the nitrous acid and its apparent conversion into nitric acid. Acting under the impression that the oxymuriate of tin, used for cutting or altering the shade of madder reds, produced its effects by some nitrous acid, or hyponitrous, contained in it, I tried the effect of the bi-oxide of nitrogen mixed with air upon strips of madder red previously damped. The action of the gas was prompt and energetic, the whole colour was changed to a yellowish shade; upon soaping, it developed into a fine pink. If the gas was too strong, or the fents left in too long, the change to yellow became permanent, and soaping only developed a cinnamon shade, which appeared to be quite as stable as other madder colours, resisting the action of soap, acids, and chloride of lime. This experiment only proves that the nitrous acid generated by the mixture of the gas with the air could produce the same effects as the oxymuriate.

Nitrous Acid.—This acid is formed when the bi-oxide mixes with air, and is the ruddy coloured gas which is produced in several cases of the action of nitric acid upon metals, when the operation is carried on in contact with the air. To procure it in its pure state, nitrate of lead is heated in a retort, when it is decomposed as follows: $\text{PbO NO}_3 = \text{PbO} + \text{O} + \text{NO}_2$. It has a suffocating effect when inhaled, supports combustion, and is readily decomposed. Its formula is NO_2 . No applications at present: the remarks under the bi-oxide are applicable here as well.

CHAPTER IV.

CARBON—LAMP BLACK—IVORY BLACK—CHARCOAL—COAL—COMBUSTION—
SMOKE BURNING—CARBONIC ACID.

CARBON is the name of pure charcoal ; it exists under many various forms. The diamond is carbon in a nearly pure state, lamp black is also carbon ; between these two extremes there are many varieties, a few only of which are known in the arts we are treating of.

Lamp Black.—This pigment is the soot obtained from the imperfect combustion of resinous or oily bodies ; finer qualities are obtained by burning turpentine, and it is said that the black used in the preparation of artists' Indian ink is derived from the combustion of camphor. Spanish black, drop black, and some other kinds used as pigments, are obtained by burning peculiar substances, not for the smoke, but for the charcoal they leave. Lamp black intended for printing purposes requires a preparatory treatment to remove certain gritty particles it contains, and which would produce abrasions of the doctor and scratches on the roller. In the first place it must be calcined at a moderate red heat in close vessels, to destroy any volatile matter present. When cool it is mixed with strong sulphuric acid till it forms a thin paste, left in contact with the acid for twenty-four hours or longer, then mixed with water and well washed until all the acid is removed. This treatment leaves the black soft and fine, it gives a good black colour with drying oils ; but in calico printing it is used with albumen for shades of grey and drab, which are very pretty in combination with other pigment colours. It is best adapted for furniture styles, hangings, &c. ; it does not resist washing very well, but never fades in the light, a desirable quality for certain classes of colours.

Animal or Ivory Black.—This substance is obtained from the calcination of bones in close vessels ; it does not contain more than from ten

to fifteen per cent of carbon, the remainder being inorganic matter. The distinguishing feature of this variety of carbon is its power of withdrawing colouring matters from solutions; it does not destroy the colouring matter, but merely forms an insoluble combination with it. Its use in the arts depends upon this property; it is applied in the refining of sugar, and in the manufacture of citric and tartaric acids.

Charcoal is produced by heating wood in close vessels, until all the volatile matters have been expelled. Its chief chemical property consists in its attraction for certain gases. One cubic inch of boxwood charcoal can absorb 90 cubic inches of ammonia gas, condensing it in its pores by some unknown force; other gases are absorbed by charcoal, but in lesser quantity. Several writers upon dyeing have sought to show a similarity between the powers of these two last forms of carbon and the power by which fibrous substances attract mordants and colouring matters. The connection, if any, is not yet sufficiently clear to form any reliable basis for theoretical considerations.

Coal.—This fuel is composed of carbon, with variable proportions of hydrogen, and only a small quantity of oxygen. The chemical tests for the value of coal can only be of value under exceptional circumstances; where coal is abundant and cheap the only test worthy of trust is the practical one of burning it and observing how much water it evaporates. The increasing pressure of the legislature for the removal of the "smoke nuisance" may justify a few observations upon the chemical part of the question, for the guidance of those interested. Soot, or the solid black matter of smoke, is a carbonaceous substance, capable of being burned and converted into colourless and consequently invisible gases. In order to burn it, there must be in the first place heat to set it on fire, and secondly, air to allow it to continue burning. The only practical difficulty in smoke burning consists in combining these two conditions, for as these carbonaceous particles are expelled from coal at a temperature far lower than that which is required to inflame them, there will always be a necessity for some source of heat to give the temperature of combustion. This heat may be obtained in various ways from the same fire-place, or from an independent fire; but a low, red heat appears essential. The admission of air may take place in an infinite variety of ways, simplest way of all by having holes in the furnace doors. There will be no difficulty about the air if the gases evolved can be raised to the requisite high temperature, that is the point where the majority of smoke-consuming appliances fail. Leaving the hinder portion of fire uncovered at each fresh charge of coal, would appear the simplest way of heating the gases evolved to the necessary temperature;

it is always effectual but hardly ever practicable, either because it requires twice as much labour on the part of the fireman, or does not allow of a sufficiently intense fire being kept up for the demands upon the boiler. There can be no doubt that a saving in coals would result from the consumption of smoke, but those schemes which promise a saving of twenty or thirty per cent, or claim to have effected it, are not to be trusted. If they are based upon any real data at all, they are not applicable to the general case. There is, indeed, a way of burning fuel with a deficient amount of air, which could give ground for such a statement. Peclet states that one pound of pure charcoal burned with a sufficient access of air to convert all the carbon into carbonic acid, will heat about seventy pounds of water from the freezing to the boiling point ; but if only so much air be admitted as allows the formation of carbonic oxide, the combustion of the same weight of charcoal would only heat fourteen pounds of water to the same degree. This case could not be imitated in ordinary circumstances, but there may be conditions where the supply of air is so deficient as to cause great loss of heat.

Carbonic Acid Gas.—This gas, a compound of carbon with oxygen, exists in the air. It has not any visible influence upon the phenomena of dyeing. The film, or crust, which forms over lime water and solution of bleaching powder, is produced by the combination of the carbonic acid of the air with the lime. The caustic alkalies absorb carbonic acid by exposure to the air, and become deteriorated.

CHAPTER V.

SULPHUR—SULPHURIC ACID—SULPHUROUS ACID—DYEHOUSE STAINS—
HYPO-SULPHUROUS ACID—SULPHURETTED HYDROGEN—SELENIUM.

SULPHUR is found in the market in three states, as flour of brimstone, which is the purest quality; roll sulphur, the second quality; and the crude sulphur, as it is imported. The only use to which sulphur is applied in the arts we are treating of is in the bleaching of woollen goods or delaines; for this purpose the crude sulphur answers sufficiently well. Sulphur does not dissolve in water, but it is dissolved by slacked lime and water, and by caustic potash and soda, with boiling, producing compounds called sulphides or sulphurets, which were formerly used in bleaching, but have been long in disuse. Sulphur enters into the composition of wool and silk, producing special phenomena with some colours to be afterwards spoken of. In the author's opinion the greater affinity of the animal fabrics for certain colours is in some way connected with the presence of sulphur in them, if they are deprived of their sulphur they are usually incapable of receiving good colours. Various attempts made to incorporate sulphur artificially in vegetable fabrics have been unsuccessful, no improvements having been obtained. A good quality of sulphur is known by its burning freely, and not leaving much residue unburnt. The actual test for the quality of sulphur is to burn a certain quantity and observe the weight of incombustible matter remaining. Roll brimstone does not leave one per cent of unburnt matters; crude brimstone leaves more, according to its degree of cleanliness; that quality is to be chosen which leaves the least residue.

Sulphuric Acid or Oil of Vitriol.—There are three varieties of sulphuric acid to be met with, the Nordhausen or fuming sulphuric acid; rectified sulphuric acid or ordinary oil of vitriol; and unrectified sulphuric acid, of a dark colour, known as brown vitriol. The Nord-

hausen sulphuric acid is seldom seen in England, it is prepared by distilling calcined sulphate of iron; its manufacture is confined to a few places on the continent. It is the strongest form of sulphuric acid, fumes in damp air like muriatic acid, whence it is called fuming or smoking oil of vitriol. It is said to be better for making sulphate of indigo than any of the other acids, producing a blue of a rich purplish shade. Whether this is really the case or not is doubtful, a couple of samples of Nordhausen acid that I experimented with did not show any advantage over concentrated English vitriol.

The rectified sulphuric acid is extensively used in bleaching, and also in dyeing and printing; its uses are too familiar to require enumerating. When at its greatest strength it marks from 169° to 170° Tw., it should not be below 166° . It is extremely corrosive, disorganising vegetable textures and organic compounds with great force. This it is supposed to accomplish by means of its great affinity for water, which causes it to take the elements oxygen and hydrogen from compounds containing them. There are some organic substances which resist the destructive action of this acid in a remarkable manner, amongst these are many of the pure colouring matters, especially alizarine, the colouring matter of madder. When sulphuric acid is diluted with water its corrosiveness is suspended; for example, cotton cloth may be kept in dilute acid for a long period without injury to its strength. But if a piece of calico were steeped in dilute acid, and then exposed to the air, the water would evaporate until the acid in the fibres became concentrated enough to disorganise them. Concentrated sulphuric acid withdraws moisture from the air, and should therefore be kept in covered vessels.

Brown vitriol, or unrectified sulphuric acid, is not so strong as the rectified, and is coloured; there is no reason why it should otherwise differ from the stronger sulphuric acid, but in manufactories where both qualities are produced it will usually happen that it is inferior in purity. Brown vitriol is usually sold at 150° Tw., and in point of acidity is about 15 per cent in value below rectified vitriol; it is not worth purchasing unless it is 20 per cent cheaper than the latter. For all purposes where great purity or the highest degree of concentration is not an object, it can be used with advantage. Brown vitriol freezes at about the same temperature as water, while the strongest vitriol requires a much lower temperature, and is hardly ever frozen in England. The freezing of brown vitriol is rather common and sometimes productive of serious accidents; it does not freeze wholly, but at the bottom of the carboy, as if it were a crystallisation; upon tilting up the carboy the solidified mass falls against the neck and may break it, scattering the still fluid

acid around. If this solidification is detected, the carboys should be placed in a warm situation or in warm water; it is not prudent to pour warm water into the carboys. I am informed that a very little water added to brown vitriol effectually prevents the solidification by cold; if the water present be more than is necessary to form the deuto-hydrate, no freezing takes place.

Impurities, Analysis, &c.—Sulphuric acid may contain several impurities detrimental to its use in the arts. It may contain lead and arsenic, which, though poisonous, are not likely to do any injury in the applications we are treating of. It may contain some of the gas, bi-oxide of nitrogen, which has been known to injure colours. This gas, which is used in the manufacture of the acid, can be largely absorbed by it in the concentrated state; if there is much present it can be detected by mixing a pint or so of the acid in question with an equal bulk of water, when the peculiar smell of nitrous acid will be perceived. A more delicate test is to pour some of the suspected acid upon clean crystals of sulphate of iron; a pink coloration deepening to claret and brown will take place if any of the nitrous compound be present. Acid containing this compound should not be employed in garancine making. it destroys colouring matter; such an impure acid has been known to completely discharge a delicate cochineal pink on silk, which was being passed in it to brighten it. A solution of ammoniacal cochineal is proposed as a test for this nitrous sulphuric acid, but is not as good as the sulphate of iron test. Some unscrupulous manufacturers add the contents of their nitre pots to the brown vitriol; so that sulphate of soda may be looked for. In all ordinary cases the hydrometer is a sufficient test for the goodness of sulphuric acid. I subjoin an abridgment of Dr. Ure's table of the strength of sulphuric acid at different densities:

DEGREE TWADDLE.	STRONG SULPHURIC ACID, PER CENT.	DEGREE TWADDLE.	STRONG SULPHURIC ACID, PER CENT.
170°	100	60°	40
162°	90	43°	30
140°	80	28°	20
120°	70	13°	10
97°	60	5°	4
77½°	50	3°	2

For exact purposes the sulphuric acid would be estimated by the amount of alkali it could neutralise, or by the weight of sulphate of baryta

produced by a given quantity of it. The compounds of sulphuric acid with the metals are called sulphates. The chemical formula for sulphuric acid in its most concentrated state is HO SO_3 .

Sulphurous Acid.—When sulphur burns in the air it produces sulphurous acid gas. It is this acid gas which is the bleaching agent in all cases where sulphur is used for bleaching woollen, silk, or straw. This gas can be procured by other means than burning sulphur, but not so economically. When strong sulphuric acid is heated along with charcoal it is decomposed, and gives off all its sulphur as sulphurous acid, the charcoal at the same time being oxidised. This gas is soluble in water to a considerable extent, and it is possible to bleach goods with such a solution. The bleaching action of this gas is not a real decolorising effect, for the colour which it appears to destroy can be revived by either neutralising or expelling the sulphurous acid, which is not the case with chlorine gas, the active element in ordinary bleaching powder. The effect of sulphuring upon woollen goods is not simply that of whitening, it gives also lustre and brilliancy, and communicates an elasticity, accompanied by a degree of harshness, easily perceptible to the fingers. A large quantity of this gas enters into some intimate combination with the woollen fibres; it cannot be removed by washing in cold or warm water, it is not expelled by a temperature of 212° Fahr., and may remain unchanged in the fibre for a space of six months at least. The sulphurous acid may be removed by alkalies and by sulphuric acid; it can be changed into sulphuric acid by the action of bleaching powder and acids, when it is readily washed out by water. The existence of this acid gas in delaines is unfavourable to the production of good colours; in woollen dyeing it is found also an obstruction, and usually it is only the finer goods, for dyeing in bright light shades, which are sulphured.

Sulphurous acid exists in the air of those towns where coal is burned, and the author believes he traced a frequently recurring accident in dye-houses to its presence. In dyehouses which are not well ventilated, there is a constant dropping of condensed water from the beams, roof, &c.; if these drops fall upon mordanted goods before dyeing, they cause the appearance of light spots in the pattern, due to the removal of a portion of the mordant. The drops have a lesser effect upon dyed goods, but still perceptible; it is upon light lilac grounds that the greatest effect is visible, frequently sufficient to render the piece so damaged unsaleable. This effect was usually attributed to acetic acid from the mordants arising with the steam and, becoming condensed, falling down again. I obtained a sufficient quantity of the droppings for analysis, and found

hardly a trace of acetic acid, but instead sulphuric acid, to the amount of 11.8 grains of the mono-hydrated acid to a quart of the droppings. The extraordinary and unexpected nature of this result caused the analysis to be questioned, but it was confirmed by a second analysis, made about a month afterwards. This is, no doubt, an unusually bad case; the dyehouse was old, in the city, and a sulphuring stove was in constant work within fifty yards of it. There can be little doubt that the sulphuric acid resulted from the oxidation of sulphurous acid carried by the air; the constant moisture, elevated temperature, and porousness of the old beams, being conditions well calculated to facilitate the change. Dr. Angus Smith states that he has found sulphuric acid as well as sulphurous in the air of towns. Some of the acid may, therefore, have been condensed upon the beams as such. The remedy for such a case as this is ventilation, and frequent washing of the roof and walls of the dyehouse. Sulphurous acid combines with bases forming sulphites; strong acids decompose these compounds, the sulphurous acid being evolved. Sulphites are antiseptic, and are used to preserve animal matters from putrefaction. A small quantity of sulphite of soda will preserve a solution of albumen and cochineal sweet much longer than they would naturally remain so.

Hypo-sulphurous Acid.—This acid exists in the hypo-sulphite of soda, a salt which has received some applications in printing and dyeing, and which, I think, is capable of extended use. A red mordant has been used, made by mixing muriate of alumina with hypo-sulphite of soda, and printing the mixture. This mordant requires no ageing, all the alumina being deposited at once, owing to the peculiar decomposition of the hypo-sulphite of alumina formed. When this salt is heated it undergoes a complete decomposition; sulphur is deposited, sulphurous acid formed, and alumina precipitates. This takes place as the mordanted cloth passes over the steam chests or cylinders, and, therefore, no hanging is required. Some practical difficulties, and its greater cost, have prevented the extensive use of this mordant. The hypo-sulphite has been employed in communicating a metallic lustre to fabrics: the fibre having been previously impregnated with a salt of lead or copper, was treated with hypo-sulphite of soda; an insoluble sulphuret was produced in the fibre, which possesses a metallic reflection. This style has, I believe, not been very successful. The hypo-sulphite of soda has peculiar solvent powers, which may probably be usefully applied. Its price, though high now, could be considerably reduced if there was demand for large quantities of it.

Sulphuretted Hydrogen.—This body is a gas frequently found in

nature. It is the active principle of the medicinal sulphuretted waters, and is produced in most cases of putrefaction of animal matters, giving rise to offensive odours. It is sometimes found in steam boilers, and, rising with the steam, occasions accidents to steam colours. Colours containing lead or copper are blackened by this gas; chrome oranges having lead bases are blackened by steam which contains sulphuretted hydrogen; and the dark metallic reflection upon some colours containing copper is owing to the same cause. Fents dipped in acetate or nitrate of lead are frequently hung up in the steaming chambers to absorb this gas. The addition of sal ammoniac and turpentine to colours appears to make them less easily acted upon by it. It is generally in water containing sulphate of lime and organic matter that this inconvenience is felt. It is worst after the water has rested for some time, as, for example, all night; it is only a common precaution to blow off a good quantity of steam each morning before using it for goods. The water in the boiler should also be more frequently blown off when it is in this state.

Selenium.—This elementary substance is excessively rare; there is no probability of its being applied to the arts. Its properties have a certain analogy to those of sulphur.

CHAPTER VI.

CHLORINE—BLEACHING POWDER—CHLORATE OF POTASH—HYDRO-CHLORIC
ACID—IODINE—BROMINE—FLUORINE.

CHLORINE is a gas of a greenish colour and suffocating smell. It was first applied as a bleaching agent towards the end of the last century, and in the same manner as sulphurous acid is now used ; that is, the material which was to be exposed to its influence was hung up in a chamber and the chlorine gas driven in. Later on, a solution of this gas in water was employed, but the discovery of chloride of lime, or bleaching powder, at once displaced these inconvenient methods of using chlorine. For scientific and manufacturing purposes chlorine is obtained by the action of hydro-chloric acid upon black oxide of manganese. It is only in the form of chloride of lime that it is practically employed.

- CHLORIDE OF LIME, OR BLEACHING POWDER.

Bleaching powder is made by causing chlorine gas to pass over slacked lime until it has absorbed as much as possible of it. Bleaching liquor is made by causing the gas to pass over or through a mixture of lime and water ; the product is the same in both cases, but in the latter it is ready dissolved, while in the former case it requires solution before it can be used. The actual composition of this body is not known ; it is usual to look upon it as a mixture of chloride of calcium and hypo-chlorite of lime, but as strong acids resolve it at once into chlorine gas and a salt of lime, it will suffice for practical purposes if bleaching powder be considered as a simple compound of chlorine with lime. Bleaching powder of good quality is a white dry powdery mass, having a faint smell of chlorine : in a damp place it absorbs moisture,

becomes wet, and then smells strongly of chlorine. It remains good for a length of time when well packed and kept in a dry situation, but is rapidly deteriorated under other circumstances. It is not wholly soluble in water, there being always an insoluble residue which consists of lime unacted upon, and the impurities originally present in the lime. For the usual purposes of bleaching, clearing dyed goods, and raising colours, only the clear solution is employed, but in a few cases where it is desirable to have free lime present, the insoluble matter is not separated. The addition of an acid to bleaching powder causes an evolution of chlorine gas, if the acid be sulphuric, with formation of the sparingly soluble sulphate of lime; if muriatic acid is used the very soluble muriate of lime is produced. The properties of chlorine, as thus evolved, may for the most part be considered as of an oxidising nature, the oxygen being supposed to be set free from water by the chlorine taking its hydrogen. That this is the ultimate action in many cases is easily proved, but there are other cases explicable on quite different grounds. In the use of chloride of lime for raising metallic colours, its action appears to be directly of an oxidising nature; the protoxides of iron, lead, manganese, and tin, are transformed into higher oxides; in raising steam blues (for which it is sometimes used) the action is of a similar nature. The phenomena attending its action upon organic matters are not so well understood, but they rest upon the great affinity of chlorine for hydrogen. The organic substance may be decomposed by its hydrogen being replaced by chlorine immediately, or it may be acted upon in a secondary manner by the elements of the water; however that may be, the energetic affinities of chlorine overcome the organisation of the body acted upon, and the result is generally a destruction of its colour, if it be coloured, and an entire change in the arrangement of its component elements.

Bleaching liquor differs in no respect from solution of bleaching powder; it is, however, preferred in some places. It has usually a density of 7° to 10° Twaddle; that which is more dense may be suspected to be purposely mixed with common salt to deceive the consumer. I have seen samples at 25° Twaddle, of which fully 15° were owing to common salt. Its real value can be tested by the method given for bleaching powder.

It is important that bleaching liquor and solution of bleaching powder should be kept in a cool and dark place. Strong direct light and a slight degree of warmth will rapidly injure these fluids, oxygen gas being evolved, and some non-bleaching salts of lime formed; the bleaching liquor appears to be more easily injured than solution of

bleaching powder, this latter contains more free lime than the former, which probably acts as a preservative.

Chloride of soda may be made by mixing solutions of chloride of lime and sulphate of soda ; the acids interchange bases, and the sulphate of lime being insoluble, falls as a precipitate. The chloride of soda has the same bleaching properties as chloride of lime ; it has been recommended in certain cases of bleaching and clearing, but I imagine it is exceedingly little used, except in linen bleaching.

It has been recently stated that by the addition of sulphate of zinc to bleaching powder, a hypo-chlorite of zinc is produced, which has energetic bleaching and discharging properties. It has been proposed to use it as a discharge for turkey red, but such samples as I have seen fall short of commercial requirements.

Testing of Bleaching Powder.—As no certain information can be obtained from the outward characteristics of a sample, it is necessary to test it chemically. This can be done in various ways, but the most convenient for occasional use is that devised by Dalton. It consists in ascertaining how much of the bleaching powder under examination is required to convert a known weight of a protosalt of iron into persalt: for $\text{Cl} + \text{HO} + 2 \text{FeO} = \text{ClH} + \text{Fe}_2 \text{O}_3$, each equivalent of free chlorine can convert two equivalents of protoxide of iron into one of peroxide. The following method and quantities of material may be taken :—Clean, good crystals of protosulphate of iron are freed from any adhering moisture by wiping with a cloth or pressure between folds of bibulous paper. of this 78 grains may be weighed out, a quantity which just requires 10 grains of chlorine to convert its protoxide into peroxide ; this is dissolved in a tumbler with addition of about twenty drops of strong sulphuric acid. Next fifty grains of the sample of bleaching powder is weighed, mixed well with a few drops of water to form a smooth paste, then with more water until it makes up exactly a thousand grains measure, when it may be transferred to a graduated tube, from which it is to be slowly poured into the solution of sulphate of iron until this latter is perfectly peroxidised. The point of peroxidation cannot be well ascertained by inspection, and it is necessary to test the liquor several times. This is best performed by the red prussiate of potash, which gives a blue colour to the solution of iron so long as any remains at the minimum of oxidation, but when it is peroxidised, ceases to give a blue. A white plate is covered with drops of a weak solution of red prussiate, and as frequently as necessary a drop of the solution from the tumbler is carried on a glass rod to one of these drops. If a blue colour is produced it is an indication that more of the bleaching powder

is required ; the process is completed when a greenish shade only is developed upon contact of the two liquids. The quantity of solution employed contained ten grains chlorine ; it is easy, therefore, to calculate how much the whole quantity would contain. If one-half of the solution was required to produce the effect of ten grains of chlorine, the whole solution would be equal to twenty grains, which being for fifty grains of the bleaching powder, would be 40 per cent of chlorine. If the graduated measure used be the ordinary burette divided into 100 equal parts of ten grains each, the per centage is found by simply dividing the number of divisions used into 2,000 : for example, 50 divisions equal 40 per cent chlorine, 60 divisions equal 33.3 per cent and so on. The highest per centage of chlorine that I have ever found in many determinations of commercial bleaching powder was 37 ; first rate qualities will indicate regularly 34 or 35 per cent. I call 32 to 33 per cent good, and below that inferior, and to be rejected unless the price be proportionally reduced. I have found some samples of bleaching powder so low as 15 and 17 per cent ; but whether this was a fault in the manufacture, or owing to some deterioration afterwards, I could not ascertain. There are better and more rapid methods of determining the value of bleaching powder than that just given, but they are more adapted for regular than occasional use, where a large number of samples have to be daily tested. Bleaching liquor can be tested in the same manner, weighing 500 grains of it, and then mixing with water to fill the burette. The per centage of chlorine is obtained by dividing the number of *grains* used into 2,000, as thus : 250 grains or 25 divisions have been required to peroxidise the 78 grains of protosulphate of iron, the per centage is therefore 8.

Chloric Acid—Chlorate of Potash.—Chloric acid in the free state is a laboratory product, but its compound with potash receives some applications in our arts. Chlorate of potash is remarkable for the amount of oxygen which it contains ; by simply heating, it will yield nearly half its weight of this gas, leaving chloride of potassium ; in contact with strong acids it is decomposed, evolving chlorine compounds which have energetic oxidising powers. Its applications in calico printing depend upon its powers of communicating oxygen to other bodies ; calico prepared with a solution of it has been used to save time in ageing ; a mixture of it with arsenite of soda is used to hasten the fixing of iron mordants ; it is employed in some steam colours, in low class reds from sapan wood, in steam chocolates, and a few other colours. It seems capable of a more extended application. This salt is sold in a remarkable state of purity by respectable houses, but being somewhat expensive

it offers temptations to adulteration ; its solution should not give any precipitate with nitrate of silver, nitrate of baryta, or carbonate of soda; its actual value is ascertained by the determination of its oxidising power, but if it stands the applications of the three tests given it may be considered good.

Hydro-chloric Acid.—This acid, better known as muriatic acid or spirits of salt, is a compound of chlorine with hydrogen ; it is a gas, and the liquid commercial acid is a solution of it in water, the strongest acid containing about one-third part of its weight of dry acid gas. The strength of muriatic acid can be very well ascertained by means of the hydrometer ; it is too cheap to make it worth while to adulterate it; such impurities as it contains are what it takes up in the course of its manufacture, these are principally iron, to which the yellow colour of the acid is owing, and sulphurous acid, or some sulphuretted compound derived from the oil of vitriol, used in the manufacture of it ; some other substances are likely to be contained in it, in small quantity, but don't interfere with its use. There are two kinds of acid known in commerce, the one called "cylinder salts," because it is derived from the manufacture of salt cake in cylinders, the other called "tower salts," because made by the method known as the tower method ; preference is usually given by the consumers to the former, and a slightly higher price can be commanded, but in what the difference consists, or if there is any real difference at all in them, the author is not informed. Spirits of salt is used for several purposes in the arts ; in bleaching it is often used instead of vitriol to make the sours which follow the chemic or bleaching powder solution, and it is thought to give better results than vitriol, especially for calico intended for garancine work ; it is the best acid for taking iron mould spots out of the cloth, applied at the full strength and washed as soon as it is seen to have dissolved the iron mould. It does not destroy cloth immediately as strong vitriol does, in fact calico will stand the strong acid for a long time provided it be kept quite immersed in it, but if calico is dipped in even very weak spirits of salt, and left in the air so as to get dry, it will become quite tender ; if a piece of calico quite dry be passed up into a jar of the dry acid gas no immediate effect is visible, but if before passing it into the gas it be breathed upon or held over boiling water, the gas is immediately absorbed and the fibrous texture destroyed, as much, probably, by the effect of the heat developed as by the greater concentration of the liquid acid formed. The usual commercial spirits of salt has a specific gravity of 1.170 or 34° Tw. and contains from 30° to 33° per cent of the dry acid. The amount of real acid can be ascertained by the quantity of alkali which it can neutralise.

The following table shows the amount of real acid in 100 parts of the liquid acid, at the strength set down :—

TWADDLE.	PER CENT.	TWADDLE.	PER CENT.	TWADDLE.	PER CENT.
40	40·77	26	26·50	12	12·23
38	38·4	24	24·48	10	10·19
36	36·30	22	22·42	8	8·15
34	34·2	20	20·28	6	6·11
32	32·2	18	18·34	4	4·07
30	30·17	16	16·31	2	2·03
28	28·30	14	14·27	1	1·00

Iodine, Bromine, and Fluorine are elementary bodies closely allied to chlorine in their general properties ; with the exception of iodine, which receives one or two applications, they are not used in the arts. Several of the iodides have fine colours, the scarlet iodide of mercury has been tried upon calico, the yellow iodide of lead has also been used as a pigment, but all the iodides are extremely susceptible to the influences of heat and light, by which they change or lose their colours, and consequently cannot be advantageously used in printing or dyeing. Iodine in solution in water is used as a test for the presence of starch, with which it gives a fine blue colour.

CHAPTER VII.

PHOSPHORUS—PHOSPHORIC ACID—SILICON—SILICIC ACID—SILICATE OF SODA—BORON—BORAX.

Phosphorus.—This interesting element has not yet received any application in dyeing or printing. In its ordinary state it is dangerous to handle on account of its easy inflammability ; but there is a modified state in which it is much less combustible, that is, the amorphous condition into which it is brought by long continued heat or the action of iodine. I tried many experiments with the amorphous phosphorus, but did not succeed in making any useful application of it ; it has powerful reducing properties, can readily bring indigo into the white state, and permit it to be fixed upon calico ; but it was difficult to manage, alkalies seemed to bring it back to the active condition, and the unoxidised phosphorus adhered to the cloth with pertinacity, and gradually seemed to burn the indigo with which it was in contact. Vapour of phosphorus has been used to produce a metallic dye upon some fibrous matters, by previously steeping them in solutions of silver, lead, or copper. Phosphorus is easily soluble in bi-sulphuret of carbon, and can be reduced to a fine state of division by melting it in urine and keeping it well agitated as it solidifies. Phosphorus forms several acids with oxygen, the chief of which is phosphoric acid, naturally existing in bones and other substances. It has not received any applications in its free state, it is a mild, non-corrosive, but yet strong acid ; it differs from all the previously mentioned acids by being fixed in fire, not distilling or rising in vapour. It forms salts with the oxides, which are as yet but little used. The phosphate of soda has been slightly used in calico printing ; it acts the part of a mild alkali, partially neutralising acids and acid salts. It has been used in dung substitutes, as a solvent

for lactarine, and in colour mixing for printing upon sulphate or citrate of iron mordants, when, by its alkaline nature, it caused the precipitation of more iron than would otherwise have been fixed, giving rise to double shades.

Silicon.—This element is the basis of sand and many minerals; it is little known in its free state. Its combination with oxygen is silicic acid, which exists pure in rock crystal, and a few other natural minerals. It has no applications as an acid, being insoluble in water in its ordinary state. Silicic acid combines with bases giving silicates, all of which are in their neutral state insoluble in water. The alkaline silicates of potash or soda are soluble in water. Common glass is a neutral or acid silicate of potash or soda, containing an excess of silicic acid; if an excess of the alkaline material be used a glass is equally produced, but it is soluble in water. Powdered flint or quartz is dissolved by a boiling concentrated solution of caustic soda, producing a silicate of soda; such a solution was known to the older chemists as liquor of flints; a solution of silicate of soda is now extensively employed in the cleansing of printed goods instead of cow dung, and is generally known as dung substitute.

Silicate of soda is made on the large scale by fusing clean sand with soda ash until a glass is produced, which is broken into small lumps and boiled with water until a solution of the required strength is obtained. Silicic acid is one of the feeblest acids, consequently the addition of any of the ordinary acids to a solution of the silicate of soda effects the decomposition of the salt, the silicic acid being displaced in a gelatinous state; if the solution be concentrated it becomes semi-solid by the free silicic acid in suspension. Silicic acid, thus liberated from its compounds, may enter into solution to a considerable extent in water and dilute acids; it is rendered insoluble by boiling or evaporation to dryness. Solution of silicate of soda is decomposed by the carbonic acid of the atmosphere; a strong and nearly neutral solution, when exposed in an open vessel to the air for a few days, becomes solid; this may form a test of the alkalinity of a sample. Silicate of soda for dung substitute should be as neutral as possible, but it is necessarily alkaline, and is not well fitted for cleansing any styles of work likely to be injured by alkalis. Silicate of soda has been used as an agent for fixing ultramarine blue and other pigment colours; the colour was ground up well with a solution of silicate at about 90° Twaddle, printed without any other thickening, dried soft and hung in a cool place, then fixed by passing in solution of muriate of ammonia or common salt. The results were not generally satisfactory, the colour was difficult to print, uncertain as to

its fixity, sometimes all coming off in the fixing liquor, and if well fixed giving an unpleasant harshness to the cloth. The inventor of this process is Mr. Kuhlmann, of Lille, who is well known for his endeavours to extend the applications of the soluble silicates. Greys for the printing machine are in some continental establishments passed through silicate of soda; they are said, when thus prepared, to give a better impression, to last longer, and to absorb less of the colour from the white piece. Silicate of soda has been mixed with soap and the compound highly commended; but it possesses no detergent properties, and can only be looked upon as an adulteration. Silicate of soda has a very injurious action upon unsoaped madder work.

Boron.—This element is contained in boracic acid and borax, which is a compound of the acid with soda. Borax is but slightly used in dyeing or printing, the few applications it has depend upon its feeble alkaline properties; it can dissolve some resinous and fatty bodies, and some colouring matters not soluble in water. The boracic acid being, like the silicic, one of the feeblest acids, is displaced by most other acids from its combinations. Borax can be advantageously substituted for carbonate of soda, where an excess of the latter might act injuriously; it serves very well to neutralise the trace of acid remaining in garancine and garanceux. It has been used to remove grease spots from silk dyed with delicate colours.

The thirteen elementary bodies already treated of are distinguished from the remainder by the name of metalloids, or non-metallic bodies, the remaining elements being metals. A chief character of the non-metallic elements is, that in combining with oxygen they produce acids, and it will be noticed that all the principal acids of a mineral origin are included in their compounds. The distinctive character of a metal is, that in combining with oxygen, it gives rise to a body which is the opposite in properties to an acid; it is either an alkali or a base, which can combine with and neutralise acids. The combination of an acid with an oxide is called *a salt*; the oxide receives the name of *base*, from an idea formerly entertained that it was the basis or more important part of the saline compound. Some metals form compounds with oxygen, which are of acid character, as chromic acid, but those instances are not numerous.

CHAPTER VIII.

POTASH, SODA, AND AMMONIA, WITH THEIR COMPOUNDS—AMERICAN
POTASH—PEARL ASH—SODA ASH—SODA CRYSTALS—SULPHATE OF
POTASH—SULPHATE OF SODA—AMMONIA—ALKALIMETRY.

POTASH and soda are oxides of two metallic substances—potassium and sodium : their metallic bases are simply chemical curiosities, very costly, and of no application in the arts. There is a great resemblance between potash and soda, and their similarly formed compounds, so that in most cases where potash is used soda could be substituted, and *vice versa*. There are differences, however, which prevent an indiscriminate use of these two alkalies.

Caustic Potash.—Caustic potash is usually sold as a liquid, which is a variable mixture of real potash and water : when the liquid is boiled down sufficiently a mass is obtained, becoming solid when cool, which is still a mixture of dry potash and water. The solid caustic potash of the druggists' shops contains usually about 20 per cent of water. Liquid caustic potash is prepared from commercial carbonate of potash, sold under the names of potash, American, Canadian, or Russian potash, or, when refined, as pearl ash. The difference between caustic potash and carbonate of potash is, that the former is free from carbonic acid, with which the latter is combined. The operation of making ordinary potashes caustic consists in abstracting the carbonic acid from them ; this is done by means of quick lime, in the following manner :—The commercial potash is dissolved in water until the solution marks about 20° Tw. ; the solution heated up to the boiling point, in an iron boiler, quick lime is added by degrees until about one-half of the weight of the potashes has

been added: the boiling is continued, with uninterrupted stirring, until a portion of clear liquor, taken from the boiler and mixed with dilute muriatic acid, gives no effervescence; the heat is then withdrawn, the clear liquor syphoned off, and boiled down in another pan to any required degree of concentration. The bottoms consist of carbonate of lime which, retaining some of the caustic potash, are usually washed once or twice with water before being thrown away. Caustic soda is made in precisely the same manner, substituting soda ash for potash.

Caustic potash and soda are more energetic in their actions than their carbonates; this can be attributed to their being free from the neutralising power of the carbonic acid. The common idea that the lime communicates some caustic principle to the potash or soda is erroneous; the lime communicates nothing, but on the contrary, removes something, which is carbonic acid.

The caustic alkalies have many applications in the arts which will be referred to afterwards. The following table will give an idea of the relative proportion of alkali and water in liquid caustic potash and soda of various strengths. For exact determination of the value of caustic solutions the chemical test given at the end of this chapter must be employed:—

TABLE SHOWING THE AMOUNT OF REAL DRY POTASH AND SODA IN ONE HUNDRED PARTS OF LIQUID CAUSTIC AT VARIOUS DENSITIES.

DENSITY, TW.	POTASH.	SODA.	DENSITY, TW.	POTASH.	SODA.
66°	28	23	40°	19	13
63	27	22	34	16½	11½
60	26	20½	29	14	10
56	25	19	24	12	8
53	24	17½	19	10	6½
50	22½	16	14	7	5
45	21	14½	10	5	3½

Carbonate of Potash.—Pure carbonate of potash is a white crystalline salt, commonly known as salt of tartar. Pearl ash and American potash consist of carbonate of potash mixed with impurities, that is, other salts of little or no value. There are no external characteristics by which the value of commercial potashes can be estimated in a satisfactory manner. Carbonate of potash is not largely employed in printing or dyeing. Pearl ash is used in Turkey red dyeing for the emulsion of

oil ; it is used as a solvent of annatto and safflower, and in a few cases of bleaching and scouring.

Carbonate of Soda.—*Soda Ash.*—Soda ash, which is extensively used in bleaching, is an impure carbonate of soda. Its whole value rests upon the amount of pure carbonate it contains. It should be quite soluble in water, of a good colour when opened, and not inclined to change by exposure to the air. Soda ash which goes yellow usually contains some sulphuretted compounds. For bleaching an ash of a bluish tint is preferred.

Crystallised Carbonate of Soda.—*Crystals of Soda.*—Crystals of soda are made from soda ash, and are a compound of dry carbonate of soda and water. In round numbers, three pounds of crystals contain two pounds of water and one pound of dry carbonate of soda. In most cases the carbonate of soda in the crystals is less contaminated with other salts than is the case in soda ash, and it should, consequently, be preferred in all delicate cases. In a warm dry situation the crystals lose water, becoming white externally ; they are not chemically changed or injured, as is vulgarly supposed, but really improved, because a given weight contains more of the alkali than previously. Carbonate of potash may be distinguished from carbonate of soda by the property which the former has of absorbing moisture from the air, becoming damp : crystallised carbonate of soda has the opposite tendency, to give up its water to the atmosphere.

Bi-carbonate of Soda.—This salt differs from simple carbonate of soda by containing twice as much carbonic acid. It is a milder alkali, and on that account receives a few applications in dyeing, where the more energetic carbonate might be hurtful. Genuine bi-carbonate of soda is a nearly pure salt, and when made red hot, to expel its water and the extra equivalent of carbonic acid, leaves pure carbonate of soda used for analytical purposes.

Sulphate of Soda.—This salt, commonly known as Glauber's salts in the crystallised state, and as salt cake in the anhydrous condition, is employed in calico printing to fix lead mordants preparatory to dyeing them orange or yellow. The only impurity likely to be injurious in sulphate of soda is sulphate of iron, which I have known to spoil work. It can be detected by the usual tests for iron. By dissolving such impure sulphate of soda in hot water, and adding carbonate of soda, all the iron may be precipitated, and a pure sulphate obtained.

Bi-sulphate of Potash.—This salt is used in some cases on account of its acidity. It contains two atoms of sulphuric acid to one of potash, so that one-half of the acid is in an almost free state. It is used in the

lower styles of work, as a substitute for tartaric acid. It requires care in its application, because there appear to be circumstances in which the bi-sulphate splits up into free acid and sulphate of potash, when destruction of fibre may occur.

Nitrate of Soda is prescribed in some receipts for calico printing; its use is owing to its being slightly deliquescent, tending to keep the colour moist and soft upon the cloth. There are many chemical salts which attract water more powerfully than nitrate of soda, but few which are so neutral in their chemical properties.

Chloride of Sodium, or common salt, is also sometimes used for the same purpose as nitrate of soda.

Ammonia.—Ammonia in its pure state is a gas, the *liquor ammonia* of medicine and commerce is a solution of this gas in water. Water can dissolve as much as 700 times its own bulk of the gas, its specific gravity diminishing in proportion to the quantity of gas absorbed. The ammonia can be expelled by heat from this solution, and in warm places the gas is always being evolved from the strong liquid, blowing out the corks, and sometimes bursting the bottles or carboys in which it was contained, producing injurious and occasionally fatal consequences. It should be always kept in a cool place. It has alkaline properties, it neutralises acids, and changes red litmus to blue, just as potash or soda. It was formerly named the volatile alkali, to distinguish it from potash and soda, which are fixed alkalies. The chief source of ammonia and its compounds is a liquor produced in the manufacture of illuminating gas; liquid ammonia and most of the ammoniacal salts of commerce betray this origin by a tarry smell, perceptible under favourable circumstances. This gas is also a product of the spontaneous decomposition of many animal matters; it is to the formation of ammonia in urine which has been long kept that this fluid owes its useful properties.

Ammonia is not largely used in dyeing or printing. In dyeing it is used to modify some shades, its general action being to darken or sadden the colour, sometimes changing the shade; with some colours it gives a very rich hue, but this is evanescent. As ammonia exists in putrified urine, it is largely used in scouring and bleaching woollen goods, and is mixed with the mordant or colouring matters in many kinds of dyeing. In all such cases it may be considered as useful in neutralising all or a portion of the acid when such is present, and in rendering greasy matters soluble in water. In calico printing ammonia serves to produce a pink from cochineal; it is used in the extraction of the colouring matter, and is added to the finished colour. It is used in a few other

cases ; in making a solution of albumen its addition seems to confer some advantages in the working of the colour ; as a gas it has been employed to fix metallic mordants and the purple from murexide. To procure the gas for such purposes, either the concentrated liquid ammonia or a mixture of slacked lime and sal-ammoniac may be used, heat causing evolution of the gas. In the gaseous state it has been used for ageing prints ; it was said to answer tolerably well for iron mordants but not for alumina, the reds dyeing up dull and of a brick red tinge. In combination with a heated and moist atmosphere it may possibly be found to hasten the ageing of heavy mordants, but I doubt if it will be of any general use, ammonia having a tendency to precipitate the mordanting oxides in a state not well adapted for receiving colours. Ammonia seems to act an important part in the formation of some colouring matters, especially of that class to which archil, cudbear, and litmus belong. The lichens from which these colours are obtained have no colour in themselves, neither does water, acids, alkalies, or alcohol extract any ; but ammoniacal liquors, such as urine, soon develop a colour in them by exposure to the air, and it appears from chemical researches, that the ammonia forms an essential part of the colour, combining with some substance contained in the lichens, and both together producing the colour. Compounds of ammonia, principally the carbonate of ammonia, exist in small quantities in rain water, and Liebig considers its softness attributable in great degree to this substance.

Testing of Ammonia—Theoretical Composition.—The value of ammonia liquor is in relation to its density, the lighter it is the better, there can be no adulteration to make it lighter ; an instrument called “ ammonia meter ” is sold for the purpose of testing it, in the ordinary way of testing the strength of liquids. For converting the indications of the ordinary English ammonia-meter into specific gravity numbers, the process is to multiply the degree by five, and subtract the product from 1,000. Thus, if the instrument indicates 20, the specific gravity of the solution will be 900, water being 1,000. Its value may be ascertained also by the quantity of acid it can neutralise after the method described further on. Here are a few results of actual trial :—

Sample No. 7,	100 grs.	neutralise	1000 grs.	test acid = 27.4 NH ₃
“ B,	100	“	1060	“ = 29.0 NH ₃
“ 71,	100	“	1000	“ = 27.4 NH ₃

The above were good qualities, and may be taken as standards.

The following table shows how much real ammonia is in a liquor of any given strength :—

TABLE OF THE QUANTITY OF REAL AMMONIA IN LIQUID AMMONIA OF DIFFERENT DENSITIES.

DENSITY OF THE AMMONIA LIQUID.	REAL AMMONIA IN 100 PARTS.	DENSITY OF THE AMMONIA LIQUID.	REAL AMMONIA IN 100 PARTS.
875	32.5	943	14.5
887	29.2	948	13.4
900	26.0	951	12.4
905	25.3	954	11.5
916	22.0	957	10.8
925	19.5	960	10.17
932	17.5	962	9.6
938	15.8	970	9.5

Good ammonia will not leave any ponderable residue upon evaporation to dryness, and should not give a precipitate with sulphuretted hydrogen, although a darkening of the solution takes place with most samples.

Ammonia is NH_3 in the gaseous state, but when combined with water it is most probably NH_4O , and not NH_3HO . It is upon the assumption that it is an oxide of the hypothetical metal, ammonium, that it is placed next to the alkaline metals, potassium and sodium. The only salts of ammonia used in printing or dyeing are the chloride of ammonium or sal ammoniac, and carbonate of ammonia.

Chloride of Ammonium.—This salt, more generally known under the names of muriate of ammonia and sal ammoniac, is largely used in certain styles of calico printing, especially in catechu colours. It is found in two different states—in large lumps of a fibrous structure, and in small crystals. The former variety has been sublimed, the latter has been crystallised from an aqueous solution. Preference is given to the sublimed sal ammoniac as being the purest. I have found samples of the crystallised sal ammoniac very pure, but often also contaminated with metallic salts, as chloride of zinc and chloride of lead. The chloride of lead is objectionable, but the chloride of zinc would not be injurious in small quantities. With the exception of a trace of iron, and that in an insoluble state, I have not found any impurity in good qualities of sublimed sal ammoniac.

Carbonate of Ammonia.—This salt has resemblance in its properties to the carbonates of the fixed alkalies. The impure carbonate, as it exists in decomposed urine, is used as a detergent. The purified

medicinal salt is expensive, and not much employed in printing or dyeing. Salts of ammonia are characterised by giving off the strong pungent smell of the alkali when they are triturated with slacked lime, or with caustic potash, or soda.

METHOD OF TESTING SODA ASH AND OTHER ALKALINE SALTS.

The commercial test of the quality of soda ash, or other alkalies, depends upon the principle that a certain quantity of pure alkali requires a constant amount of acid to deprive it of its alkaline characters, and as the amount of pure alkali varies in any mixture so will the amount of acid required to neutralise it. The chief character of alkalinity is that of changing vegetable red colours to blue, while acids do the reverse. Paper coloured red or blue, sold as litmus paper, is very suitable for ascertaining the acidity or otherwise of any solution. The process of testing consists in pouring acid of a known strength upon a weighed amount of the alkali to be tested until the acid character just predominates, and calculating its value from the quantity required. A graduated tube, called an alkalimeter, is usually employed. It holds 1,000 grains of water, and is divided into 100 divisions, each division equal to 10 grains water.

Sulphuric acid mixed with water until it marks between 10° and $10\frac{1}{2}^{\circ}$ Twaddle, is of such strength that 20 grains measure of it (that is, two of the marked divisions on the alkalimeter) will neutralise one grain of pure dry caustic soda. But it is not safe to depend either upon the goodness of the vitriol or the correctness of the Twaddle, and as a large quantity of this test acid can be made at once, it should be made exactly right, and this may be done as follows:—Mix any quantity of vitriol and water together until the mixture, when cold, stands at 12° or 13° Twaddle. This will be too strong, and it is to be ascertained how much water must be added to make it the required strength. Some pure carbonate of soda must be obtained. It can be made by drying crystals of soda and making them hot, or by calcining good bi-carbonate of soda. Eighty-five grains and a half of pure carbonate are equal to fifty grains of pure soda, and this quantity must be dissolved in a basin, in a small quantity of boiling water, and the acid added from the alkalimeter until the alkali is neutralised, that is, until litmus paper is just turned red by the liquor. Suppose it has taken eighty-seven of the hundred divisions, the acid is too strong, because it should have taken the whole hundred. It must then be weakened with water to that extent, and this can be done by putting eighty-seven divisions of test acid into the

alkalimeter and making up with water to the top line. Now the whole alkalimeter full, containing only eighty-seven of the acid, and this quantity being just sufficient by experiment to neutralise the fifty grains of pure soda contained in the carbonate, it follows that an acid liquor is obtained, of which 100 divisions neutralise 50 grains soda, and, therefore, each division neutralises half a grain. The whole of the acid which was made must be weakened down in the same manner, putting 13 of water to 87 of acid, and if the first determination was properly made the test acid will be correct. It is only half the strength usually recommended in chemical treatises, but it is quite strong enough, and twice as delicate in its indications as the usual test acid. In stoppered bottles it will keep for any length of time, but it is prudent to test it from time to time to be sure that no accident has happened to it.

Testing Soda Ash.—Take 100 grains, dissolve in a couple of ounces of hot water, and add 80 divisions of the test acid gradually; if added too fast, the effervescence produced by the escape of carbonic acid may carry the liquor over the sides of the vessel, and no inconsiderable quantity be lost. A solution of blue litmus may now be added to tinged it, or three or four bits of blue litmus paper put in the liquor, and then the acid gradually poured in, with perfect stirring, until it is seen that the litmus is changing colour. A drop of the liquor, from a glass rod, should now be put on some blue litmus paper, and if it turns it a sharp bright red it is quite done. If the drop does not change the colour of the blue litmus in a distinct manner more acid must be added. If the drop turns the litmus paper to a claret colour it shows the action is nearly complete, and only a small quantity of acid must be added to produce the sharp clear red which indicates the presence of a slight excess of the test acid. Beginners are liable to consider the action complete before it really is, and to mistake the claret colour for the red. A drop of the test acid in a wineglassful of water may be used, as giving the colour to be arrived at. In making close determinations I have tested soda ash, as a general rule, quite hot, and towards the end boiled it. This is not really necessary, but it avoids all ambiguity from the carbonic acid, and the testing is finished more quickly. Some samples of soda ash contain sulphurets and sulphites, which may give a false appearance of strength. This source of error may be removed by taking the hundred grains to be tested, mixing it with about ten grains of chlorate of potash, and calcining at a red heat, and then testing in the usual way. The oxygen of the chlorate converts the sulphurets, sulphites, and hypo-sulphites into sulphates, which are not affected by the test acid.

Caustic soda and crystals of soda can be tested by the same test acid, and in the same manner.

Pearl ash, American potash, caustic potash, and carbonate of potash can be also tested by the same acid, but it then requires a calculation to bring the soda indications to potash results. If a sample of potash took eighty divisions, this would be equal to forty grains of soda; but the saturating power of potash is less than that of soda in the proportion of 47 to 31, and it takes, therefore, a larger amount to neutralise the acid. The equivalent in potash is to be obtained by rule of three—

$31:47::40:x = \frac{47 \times 40}{31} = 60.6.$ In practice the simple rule, and quite close enough, is to add one-half to the number of measures taken. For example, having taken 80 divisions, 40 would be added, and called 120, equal to 60 grains of real potash.

I give here a number of determinations of the alkali in soda ash, potash, &c., as a guide to what may be expected, and what should be required in trade.

Soda ash B, September 25, 48 per cent.—Passable quality.

Soda ash BT, September 29, 41 per cent.—Bad, returned, or else a discount of 18 per cent taken off.

Soda ash T, October 21, 49½ per cent.—Good average.

Soda ash J, July 5, 51 per cent.—Good, but containing sulphurets and sulphites.

Soda ash K, February —, No. 1 cask, 46 per cent.	} Irregularity to be complained of.
Soda ash K, February —, No. 2 cask, 46 per cent.	
Soda ash K, February —, No. 3 cask, 53 per cent.	
Soda ash K, February —, No. 4 cask, 47 per cent.	

Soda ash C, February 15, No. 1 cask, 54 per cent.	} These are the strongest ashes I have tested.
Soda ash C, February 15, No. 2 cask, 55 per cent.	

Soda ash HLP, April 21, 43½ per cent.—Rejected as too weak.

It is not necessary to multiply examples: this list contains the best and worst ashes I have met with. The average is 48 per cent on a large series of testings; soda ash should not be complained of at 48, but if one degree lower it is weak. In a number of samples there should be as many over 49 as under it, unless the maker states its strength and charges in proportion. For a sample weaker than guaranteed, the deduction to be made is double the per centage difference, i.e. if the strength should be 50 and it is only 45, the deduction from the charged price should be ten per cent and not five, because if only fifty is the useful matter, the consumer has to pay equally for the other fifty, and should have his deduction on both of them.

SAMPLES OF POTASHES.

Pearl ash T.....	February 20.....	54 per cent KO.
American potashes O...	January 29	60 per cent KO, colour light.
American potashes P...	February 27.....	55 per cent KO, dark coloured.
Pearl ash A.....	February 9.....	54 per cent —.
Pearl ash T.....	July 7.....	56 per cent KO.
American potashes T....	July 7	63 per cent KO.
Caustic potash	54° Twaddle.....	21 per cent KO.
Caustic potash	17° Twaddle.....	7½ per cent KO.

The average for pearl ash is from 54 to 56 per cent ; that of American potashes cannot be stated, there is no regularity about them, but those put down above were received as good.

The estimation of the carbonic acid by Will and Fresenius' method can seldom be necessary in practice ; nor if the amount of carbonate of soda be good, can it often be of much consequence what the other constituents are. For soap making, for bleaching, and for the preparation of rosin, it is well to have a soda ash to begin with not less than 48 per cent. If it be less than that, although its price be low in proportion, there is an accumulation of foreign salts likely to act injuriously. Soda ash for bleaching should be free from iron, and not leave any insoluble matter, and should not contain soda in the caustic state.

Here are analyses of two good samples of soda ash which I had occasion to make in January, 1854, and one not so good made more recently :—

	No. 1 T & C.	No. 2 B & B.	No. 3 B & C.
Carbonate of soda.....	82.9	86.3	78.10
Caustic soda	1.5	1.3	1.76
Sulphate of soda.....	7.3	4.2	12.15
Chloride of sodium.....	8.9	9.1	6.13
Silicate of soda.....	0.4	0.35	1.80
	101.0	101.25	99.94

Besides which could be detected traces of sulphites of soda and some cyanogenous compound. The sample of soda ash mentioned above as containing fifty-five per cent of alkali, would be equivalent to 94 of the carbonate, and there could only be 6 per cent of foreign salt present.

CHAPTER IX.

THE ALKALINE EARTHS : LIME, MAGNESIA, BARYTA, AND STRONTIA, WITH THEIR COMPOUNDS.

LIME.

QUICK lime, prepared by expelling the carbonic acid from the carbonate of lime, is the oxide of the metal calcium. Its uses in bleaching and dyeing are dependent upon its alkaline properties. Presenting some analogy with potash and soda, it differs from them in being much less soluble in water, and consequently in many cases much less energetic in its action ; but there are conditions under which it may act with even greater power than the more soluble alkalies.

Slacked lime is a combination of water with lime ; very considerable heat is evolved in the combining of water with lime. Two cases have come under my notice where the accidental admission of water to lime in wooden vessels has caused sufficient heat to set fire to the wood. Lime is often kept in old hogsheads on print and dyeworks, and care should be taken of the possible occurrence of such an accident. Lime, mixed with an additional quantity of water, forms what is known as milk of lime ; it consists of particles of hydrate of lime suspended in lime water. When milk of lime is allowed to stand quietly, the particles of lime subside, and a clear liquid is left, which is lime water. Lime water has alkaline characters, but very weak on account of the small quantity of lime it contains : a gallon of lime water will not contain more than a quarter of an ounce of lime, nor can the strength be increased by concentration of the liquid. Hot water dissolves less lime than cold water, which is contrary to the usual law of solution ; the most reliable experiments show that it would require a gallon and a half of boiling water to dissolve as much lime as a gallon of cold water. The first

water obtained from lime is usually stronger than the subsequent ones; this arises from a minute quantity of the alkalies, potash and soda, being present and being all dissolved at once: the second and third waters from the lime are pure lime water. It is a question how many waters can be obtained from lime bottoms. That depends upon the quality of the water used. Pure water would continue to dissolve lime and yield good lime water many times; but water containing bi-carbonate of lime will not yield above three or four good lime waters, and that only with active stirring and raking up of the lime bottoms. Water containing organic matters does not yield many lime waters; in both cases the lime is coated with a pellicle of insoluble precipitated matters which prevent the access of the water to it. The fact that cold water is a better solvent of lime than boiling water has induced some scientific men to advise that it should be always used cold, as then a greater quantity of the active material is in solution. But this advice is not founded on scientific principles, for it is well known that heat gives an energy to the action of chemical substances, the absence of which could not be compensated for by the use of a tenfold quantity of the material. In the general applications of lime in dyeing and bleaching, it is used in the milky state, that is, containing undissolved lime, and though it is contrary to theory to suppose that the undissolved lime is chemically active, there can be no doubt that, besides acting as a reserve for maintaining the water saturated with lime, the finely divided particles have an action which is at present not to be distinguished from what is considered purely chemical. It will be shown that lime can disorganise vegetable textures, and that some cases of tender cloth in bleaching are attributable to the action of milk of lime, while it cannot be shown that clear lime water produces such effects. Lime combines with all acids, neutralising them and forming salts of lime or calcium; the film or crust which forms upon lime water exposed to the air is carbonate of lime, the carbonic acid being derived from the air. Lime is a powerful base, and can displace the oxides of the metals proper from their combinations, itself combining with their acids. Upon this property depend the uses of lime in raising colours, in indigo dyeing, or other cases. In raising or fixing the buff from salts of iron, for example, the cloth containing acetate or sulphate of oxide of iron in its pores is passed into milk of lime, the lime combines with the acid, forming acetate or sulphate of lime, while the oxide of iron, deprived of the acids which made it soluble in water, rests upon the fibre. The action of lime in bleaching depends also upon its powerful basic properties, as will be explained in the proper place.

Carbonate of Lime.—The only form of carbonate of lime familiar to the dyer and printer is chalk, which, being ground, is used in some few cases as an anti-acid. It is very suitable for this purpose, especially when an excess of alkali would be injurious. Chalk does not completely neutralise diluted acid liquors. A beck or cistern of dye liquor can have an acid reaction to test paper, though an excess of chalk be present; and this acidity, though small, would be too much for some styles. In such cases carbonate, or bi-carbonate of soda, may be employed, or even lime water, if cautiously used. Ground chalk, though cheap, is liable to adulteration with sand; I have found ten per cent of coarse sand in ground chalk; it could not be observed by inspection, but was easily shown by treating the chalk with muriatic acid, which left the sand undissolved. The quality of chalk is liable to variation, and all kinds are not equally suitable for the calico printer's use; some varieties contain magnesian salts, others a good deal of silicates. Chalk is frequently used in madder dyeing, and care should be taken that it is tolerably pure. The lighter variety appears better adapted for general use than that which is dense and heavy; good qualities do not contain more than five per cent of moisture. Carbonate of lime is insoluble in water, but forms a soluble combination with another atom of carbonic acid, which exists in many natural waters. The extra atom of carbonic acid is so loosely held, that it escapes by simple agitation of the liquid, or exposure to the air, leaving the ordinary carbonate of lime in the insoluble form. Some spring waters are so saturated with this solution of carbonate of lime, and let it fall out so easily, that it collects in stony masses about the source, deposits in boilers fed with it, forming incrustations, and is productive of many inconveniences in application. Some idea of the amount of carbonate of lime dissolved in water may be formed from the statement of Bischof, that a single small stream in Germany carries away each year as much of this salt as would be equal to a cube of building limestone of one hundred feet, in lateral dimensions.

Sulphate of Lime.—This salt is an abundant natural product. It is known as gypsum, and when deprived of its water by roasting or calcining, forms plaster of Paris. It exists in most spring and river waters, and affects the dyeing of certain colours, as alluded to. It is only slightly soluble in water; it is produced when sulphuric acid and a soluble salt of lime are mixed together, and is the precipitate which forms when sulphate of alumina or alum is mixed with acetate of lime in the making of red liquor. It is sometimes used in finishing to give the appearance of body to inferior qualities of calico.

The Nitrate and Muriate of Lime are not generally known in trade. They are both deliquescent salts, and have been sometimes used in colour mixing on account of that property.

Acetate of Lime in an impure state is largely used as the most convenient source of acetic acid for the formation of the acetates of iron and alumina. It is sometimes sold in the dry state, but more usually in a liquid form. It is very variable in quality; the hydrometer test is no indication of its value. The whole value lies in the amount of acetic acid present, the method of determining which will be given under that acid.

Phosphate of Lime.—It was long ago known that the bones of animals which ate madder were tinged red; the conclusion that it was the phosphate of lime which attracted the colour was too hasty; it now seems probable that some of the animal matters also present in the bones had more to do with it than the mineral matter. Nevertheless, phosphate of lime has some attraction for colouring matters. If an excess of ivory black or calcined bones be digested with citric acid, phosphate of lime is dissolved, which being properly applied to calico, can be shown to form an intimate connection with it, and to have also an affinity for colouring matters. It does not attract so much colouring matter as to be of value as a mordant, for the shades it yields are poor in depth and of a dry absorbent character. In repeating this experiment care must be taken that there is no iron dissolved by the acid, or this will entirely change the nature of the colours produced; if iron exists in the liquor, it can only be precipitated by the prussiate of potash.

The best test for lime in solution is oxalate of ammonia, which gives a white precipitate provided the solution be neutral; in moderately strong solutions sulphuric acid gives a bulky precipitate of sulphate of lime.

MAGNESIA.

Magnesia has an alkaline reaction, but feebler than lime. It is very sparingly soluble in water, it is expensive, and but little used in calico printing. Such uses as have been found for it depend upon its power of neutralising acids and exerting a slight alkaline reaction. It has been used with archil in Broquette's patented method, in the mixing of the colour from the modified archil colours of Guinon, and as forming a discharge for indigo colours, in combination with red prussiate of potash. Caustic magnesia has a powerfully injurious action upon dyed colours. If pieces of various colours from madder, indigo, logwood, or garancine,

be boiled in water containing magnesia in suspension, they are in a short time surprisingly deteriorated and permanently injured. The cause of this action is not clear, probably the magnesia may displace some of the mordant of the colours, and not being itself able to yield bright lakes with colouring matters, spoil the shades. Magnesia added to dyewoods, or to the water used in dyeing, is extremely detrimental—one per cent of the weight added to a madder dye will entirely stop the dyeing, and a less quantity is very injurious. Magnesian salts are present in many waters, and may be the cause of failures in dyeing. The neutral salts of magnesia are not injurious to dyeing, it is only calcined magnesia and the carbonate which act in the manner described. A water containing magnesia may be corrected by the adhesion of a minute quantity of oxalic acid or a larger quantity of sal-ammoniac.

Sulphate of Magnesia, or Epsom Salts, is used in calico printing to fix the lead mordant on chrome orange styles, where colours are worked in combination, which would be injured by sulphuric acid ; sulphate of soda being cheaper, is generally used instead of Epsom salts. The remaining salts of magnesia are of no interest in a practical point of view.

Baryta.—This earth exists in tolerable abundance in England and Scotland in the state of sulphate and carbonate. It has not been yet employed as a chemical agent in manufacturing operations. Caustic baryta has similar properties to quick lime ; it is more soluble in water, and would no doubt possess some advantage over it if practically accessible. Sulphuret of barium is easily prepared by heating the native sulphate with carbonaceous matters ; it is soluble in water and has alkaline properties ; it has no applications yet, but is likely to receive some. Sulphate of baryta in a finely ground state, sold under the name of mineral white, has been used in finishing inferior qualities of calico.

Strontia is an earth closely resembling baryta in its properties ; it is sufficiently abundant, but has not yet received any practical applications.

CHAPTER X.

ALUMINA AND IRON, AND THEIR COMPOUNDS : ALUM, COPPERAS, ETC.

ALUMINA is the oxide of the metal aluminum, the base of common alum and all the modified compounds made from it. In the impure state and in combination it is a very abundant substance, forming a large portion of clay and of many minerals; it exists in a state easy to be extracted in certain slaty shales; it constitutes the bulk of pipe clay, from which large quantities of aluminous compounds are made. Alumina, combined with water, may be obtained in a jelly-like state by adding ammonia to a clear solution of common alum; it precipitates, and may be collected upon a strainer or filter, and the excess of ammonia washed out by water. In this state it is called hydrate of alumina, and can be used to make any salt of alumina by dissolving it in the appropriate acid; this hydrate of alumina is used for the purpose of making coloured lakes, which are employed in calico printing; it is soluble in caustic soda and potash, forming the aluminate of potash or soda. Alumina in this moist, soft condition, is distinguished for its inclination to attract colouring matters, and for its displaying the colour with brilliancy; the combinations of alumina and colouring matters are called "lakes." The affinity of alumina for colouring matters is so great, that if a sufficient quantity of it be added to a watery extract of logwood, or other dye-wood, it will in a short time attract all the colouring principle of the wood to itself, and leave the liquor colourless; it is in such a manner that Coëz' lakes are prepared. It is this great affinity of alumina for colouring matters which makes alum so valuable a chemical to the dyer and printer; the other substances which are present in alum serve no purpose but to keep the alumina it contains in a proper state to combine either with the cloth or the colouring matter, as the case may be.

Alum.—Alum is composed of sulphate of alumina and sulphate of potash, combined with water ; it is termed in chemistry the double sulphate of alumina and potash. There are two kinds of alum in use in England, which will be called here by the names of potash alum and ammonia alum respectively ; the ammonia alum contains sulphate of ammonia in the place of sulphate of potash, without any other difference. The greater part of the alum in trade in this country is the ammonia alum, only a small portion is potash alum. For the majority of uses to which alum is applied it is indifferent which of these two kinds is taken ; the ammonia alum has a slight advantage in strength, but it amounts to very little. There are some cases where ammonia alum cannot be applied, and which absolutely require alum free from ammonia ; there is no ascertaining by appearance which is ammonia and which is potash alum, they are both exactly alike in their crystals and external characters, but a chemical test can be readily applied. It consists in mixing the alum to be tested, in powder, with either strong caustic soda, or dry slacked lime ; if the odour of ammonia is perceived, it may be concluded that the alum in question is an ammonia alum, if not it is a potash alum. There are, however, alums which contain both potash and ammonia, and though the test serves to show if there be any ammonia present, it gives no indication of the quantity. Alum in large lumps is more likely to be pure than that which is sold in small crystals, known in trade by the name of ground alum ; the powdery alum usually contains a small per centage of water in excess, and more frequently contains small quantities of iron than the lump alum. Iron is the only impurity likely to cause trouble in alum ; sometimes it is present in such quantities as would cause it to seriously injure colours that it is applied to, but more generally it is in smaller quantities. Alum containing iron is generally capable of being detected by the appearance and taste ; it is not so firm as pure alum, softer and crumbly, it has an inky taste easily distinguishable from the astringent taste of pure alum, and if it has been exposed freely to the air for a length of time, will show marks of iron rust in various parts. As a chemical test, logwood liquor and tincture of nut galls can be used, also solution of yellow prussiate. M. Persoz recommends as a reliable test the addition of an excess of tartaric acid to the alum, and then potash in excess, when a drop of hydrosulphuret of ammonium being added, the minutest trace of iron can be detected, and its quantity approximately ascertained by the colour it communicates to the liquor.

There is, or was formerly, a kind of alum called roach or rock alum, also a Roman alum, but whether these are the same or three distinct

alums is not clear ; this alum had some properties different from common alum, but which can be communicated to it, and is said to have been highly esteemed by dyers ; the only difference was, that it contained less acid and more of the aluminous base ; it gave up its alumina more easily as a mordant, and dyed better colours and with less trouble. The additions of ground chalk, slacked lime, soda, potash, or crystals of soda, to common alum, which are made in so many cases in dyeing and mordanting, answer the purpose of neutralising part of the acid in alum, and put it in the same condition as this older alum. A species of alum can be obtained in crystals by operating in this manner, which is called cubical alum, from crystallising in that form, and has the property of letting part of its aluminous base fall out when a solution of it is boiled. If there be any cloth to take up the alumina, of course it will receive a more plentiful supply than in the case of common alum, which undergoes no change by boiling. Alum contains about half its weight of water, and only about 10 per cent of alumina ; it is always acid, it does not dissolve easily—a gallon of cold water not taking up much more than a pound. The uses of alum in dyeing and printing are numerous, all depending upon the affinity which the alumina possesses for colouring matters on the one hand, and the attraction it has for the vegetable or animal fibre on the other. It is the intermediary agent which brings on an union of these two bodies, which of themselves have little affinity.

Sulphate of Alumina.—This salt may be called alum without the potash or ammonia ; it contains all the essential elements of alum, the aluminous base and the acid which dissolves it, yet it does not answer in many cases where alum is used. This is partly owing to its being less pure, and perhaps partly owing to some modifying action which the sulphate of ammonia and potash exercise in alum, being wanting in it. It makes good red liquors and alkaline alumina mordants, and, no doubt, when its manufacture is more thoroughly understood, and it is sent out more regular in its composition, it will be used in most cases where alum is now employed. It is stronger, weight for weight, than alum, containing at least a third more alumina, and consequently going further ; but, as intimated, it is not constant in its composition. The author has found samples containing as little as eleven per cent of alumina, and as high as sixteen per cent ; the amount of acid sometimes above and sometimes below what the quantity of alumina requires, the water also varying in the same manner. A good deal of discredit has, no doubt, fallen upon it on account of this irregularity. It often contains a small amount of iron, and generally presents traces of Prussian blue, the prussiate being employed to purify it from iron. The appear-

ance of the sulphate of alumina is not a reliable guide to its quality ; it is often deceptive, a sample that appears soft and moist actually containing less water than another sample which is firm and hard ; its apparent dryness seems to depend upon the set of the small crystals. The amount of its different constituents can only be ascertained by regular analyses. It is better known as patent alum than by its regular chemical name.

Nitrate of Alumina and Muriate of Alumina are sparingly employed. They are made by mixing, in the first instance, alum and nitrate of lead ; and, in the second, alum and muriate of lime ; the sulphate of alumina answering the same as alum. Nitrate of alumina is easily decomposed, parting with its acid at a comparatively low temperature. Some of the uses of the nitrate of alumina are more referable to its acting as a convenient acid salt than as an aluminous compound, thus, its use in blocking upon chrome oranges, to change them into yellow ; its utility in some steam colours seems to be referable to the oxidising action of the nitric acid upon the colouring matter. On account of this ready splitting up of the elements of nitrate of alumina into the acid and earth, it must be sparingly and cautiously used as an ingredient in colours printed on calico.

Chloride of Aluminium, or Muriate of Alumina, is like the nitrate with regard to stability ; a solution will act nearly as vigorously as an acid, as if no alumina was there to neutralise the acid it contains.

Acetate of Alumina or Red Liquor.—This important mordant is made by mixing together acetate of lead and sulphate of alumina. A double decomposition ensues, and there is produced acetate of alumina which remains in solution, and sulphate of lead which, not being soluble in water, falls down as a sediment. Acetate of lime is employed, for economical reasons, instead of the sugar of lead ; and alum can be, and is frequently used instead of the sulphate of alumina. In the chapter on mordants more particulars, in detail, will be given upon red liquor. The amounts of acetate and alum are not exactly proportioned so as to decompose one another perfectly, there is always a deficiency of acetate. It is not found necessary to produce a pure acetate of alumina, it giving no better results than a mixture of a certain amount of acetate and sulphate.—*See also acetic acid*.

Oxalate of Alumina has been a little used in steam colours. It can be best prepared by dissolving freshly precipitated alumina in a warm solution of oxalic acid. It parts with a portion of its alumina to cloth at natural temperatures, but yields much more under the influence of heat, as in steaming.

Aluminate of Potash (alkaline pink mordant).—In this compound the alumina, instead of being dissolved by an acid, is kept in solution by an alkali, it being a property of this substance to be soluble in either acids or alkalies. If caustic potash be mixed with a clear solution of potash alum, the first effect is to produce a bulky gelatinous precipitate, which does not dissolve in water, but, if more caustic be added, the precipitate is re-dissolved and the liquor becomes clear again; the alumina was in the first instance thrown down, because the potash took the sulphuric acid, and it was then re-dissolved, because, all the sulphuric acid being combined with potash, any more potash added was at liberty to act upon the alumina, forming a soluble compound with it, called aluminate of potash, from the assumption that the alumina, which formerly acted the part of a base, now fulfils the duty of an acid. The way in which the alkaline pink liquor is made on the large scale is to take caustic potash at a strength of from 40° to 50° Twaddle, heat it nearly to the boil in an iron or copper pan, and then put in, by portions, the requisite quantity of alum or sulphate of alumina in coarse powder; the heat of the liquor must be maintained, and all the time that the alum is being added it must be well stirred with an iron rake until the lumps have dissolved; to finish up, it should be boiled a short time, say fifteen minutes, and then allowed to cool in the pan. As it cools, crystals settle out, partly falling to the bottom, partly adhering to the sides of the pan; these crystals are sulphate of potash, they crystallise out because they are only soluble to a small extent in the strongly alkaline liquor. There is also in most cases a sediment of a light colour at the bottom of the pan, which is alumina not dissolved; there should not be much of this, it is a sign of carelessness in the manufacture, attributable to the alum not being crushed fine enough, or the stirring not being properly attended to. About $3\frac{1}{2}$ pounds of alum to a gallon of caustic, standing at 40°, gives a good result; if sulphate of alumina be used, the same quantity may be taken, but then the caustic must be stronger, it should stand at from 50° to 55°. Ammonia alum will not do to make alkaline pink, it never gives good results, and must be always much more expensive than either potash alum or sulphate of alumina, requiring more potash than they do; the caustic, instead of having merely to free the alumina from the acid it was combined with, has to free the ammonia also, and consequently requires either an extra quantity or can only perform its office in an inefficient manner. It is possible to use ammonia alum, but, as stated, it takes more caustic, and gives, even then, bad results, the alumina soon begins to fall out, and the liquor becomes weaker every day. With regard to the use of

sulphate of alumina and regular alum, it appears to be indifferent which is used, provided the difference in alkali be made which the different amount of acid in these two salts necessitates. Caustic soda cannot be well employed instead of caustic potash, principally because the sulphate of soda which is formed does not crystallise out like sulphate of potash; such crystals as do form are bulky and hold much liquor, while a good deal of the sulphate of soda remains in solution and impedes the action of the alumina contained in it. Another method of preparing this mordant consists in first making the alumina, and then dissolving it in caustic: it might be more economical on a large scale, but would not answer so well on a printworks. Aluminate of soda made by this method would not have the objections mentioned above, but the author is not aware of its having ever been used. Alkaline pink liquor can be made without heat, but it appears from the author's experiments not to be so good as that made by boiling, and requires very strong caustic to make the liquors of proper strength.

Aluminate of potash should be kept in a covered vessel, as it is injured by long exposure to the air: it is best kept in iron or copper vessels, acting injuriously on wood and earthen vessels. Any acid or other substance which takes up the potash throws down the alumina; the carbonic acid in the air does this in a slight degree, when the liquor is exposed to it, in thin films, and for a long time. Most salts, when mixed with it, precipitate the alumina, as, for example, sal ammoniac, sulphates of magnesia, zinc, and all other soluble metallic salts. This is attributable to the acids of the salts taking up the potash, and then both the alumina and the oxide being thrown down together. Cloth mordanted with alkaline pink is dunged with addition of some of these salts to fix the alumina; sal ammoniac or a salt of zinc being the most frequently used. The oxide of zinc precipitated has very little affinity for the cloth, and is detached in washing; but if any iron be present it precipitates at the same time as the alumina, and according to the quantity which may have been present, it dyes up in madder a chocolate or dull lilac instead of a red.

Pipe Clay—China Clay.—These two substances are aluminous compounds. They are used in printing as resists, and in finishing (china clay principally) to give body to the cloth. Neither of them has any chemical action whatever. Their function is entirely mechanical; as a resist they simply interpose their particles between the chemicals, or the dyes, and the cloth, and receiving them, prevent them touching the fibre: they, having no affinity for the fibre, wash off and take the deposited matters with them. These two earths are well fitted for the

purpose; they cover the fibre well, their fat nature keeps them in close contact with it, and their chemical neutrality prevents any change in their constitution affecting their adhesion to the part to be protected.

Analysis of Salts of Alumina.—Mordants will generally be tested in the practical way, that is, trying them upon fents or pieces against a standard quality; but there is sometimes a necessity for ascertaining the amount of alumina in the compounds used in printing and dyeing. The alumina is completely precipitated from acid solutions by an excess of ammonia; it is simply necessary to collect the precipitate, wash, and dry, to know the amount of alumina in any compound. In commercial acetate of alumina, or red liquor, the alumina varies from 1.6 to 4.5 per cent; from 3.5 to 4.5 is the quantity in strong red liquors, lesser quantities are present in the red liquor for mixing with iron liquor for chocolate shades. In an analysis of red liquor, the determination of the amount of acetic acid is quite as important as the alumina, which might possibly be all present as alum.

In sulphate of alumina the amount of alumina can be ascertained by exposing it to a low heat until all the water is expelled, and then to a bright red heat, which drives off the acid, leaving the alumina pure if there be no other solid matters in the salt. This method is rapid and reliable, if the required heat can be obtained. The regular analysis consists in determining the water at a temperature of 260° , precipitating the sulphuric acid by chloride of barium, and then the alumina by ammonia. I append the results of some analysis I have had occasion to make:—

	No. 1.	No. 2.	No. 3.	THEORETICAL.
Alumina.....	11.0	14.9	16.60	15.42
Sulph. acid.....	33.1	37.1	33.36	35.99
Water.....	55.9	48.0	50.20	48.59
	100.0	100.0	100.16	100.00

No. 1 is very bad, and some work had been spoiled before it was submitted to me for analysis. No. 2 is the average strength, and which, if free from iron, I call good. No. 3 is an exceptional specimen, very rich in alumina, and which answered exceedingly well in practice. The formula from which the theoretical result is calculated, is $\text{Al}_2\text{O}_3, 3\text{SO}_3 + 18\text{HO}$. The No. 3 must have been a mixture of some more basic sulphate with the regular ter-sulphate.

Alum is not subject to variation in its alumina, and will seldom require more than a qualitative examination for iron or dampness. Ammoniacal alum contains more alumina than potash alum, and consequently is preferable in all cases where the sulphate of ammonia is not

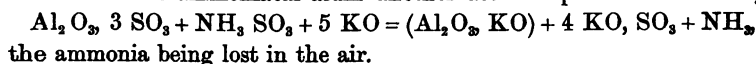
objectionable. Here is the per centage composition of the two alums, assumed as pure :—

	POTASH ALUM.	AMMONIA ALUM.
Alumina	10.83	11.34
Sulphuric acid.....	33.71	35.29
Water.....	45.51	49.62
Potash.....	9.95	.....
Ammonia.....	.....	3.75
	100.00	100.00

Cubical or Roman alum contains a less quantity of acid ; probably the sulphate of alumina, or a portion of it, is present under the form of bi-sulphate of alumina, or it may be, even of mono-sulphate. Burnt alum, that is, alum from which all the water is driven off by heat, is a white, spongy mass. In pure or commercially good alum no change takes place by a moderate heat, and a solution of the burnt alum should possess just the same properties as if it had not been calcined. At a temperature somewhat higher than that at which the water is expelled from the alum, acid is driven off, and it is possible that in this way alum might be brought to the cubical or basic state. At a strong red heat all the sulphuric acid combined with the alumina is expelled, and a mixture of alumina and sulphate of potash left in the case of potash alum, or alumina only in the case of ammoniacal alum. In solution the behaviour of ammonia and potash alum is, for the great majority of cases, identical. The loss which occurs in using ammoniacal alum instead of potash alum for making the alkaline alumina mordant, is explained by the following formula. In the case of potash alum, we have

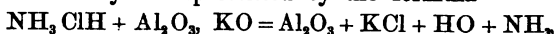


in the case of ammoniacal alum another atom of potash is necessary,



Alkaline pink liquor, to give the darkest shades, should contain not less than 4.5 or 5 per cent of alumina, and about three times that quantity of potash, taken as anhydrous. The quantity of alumina is ascertained by precipitating with chloride of ammonium ; the potash can be dosed by the alkalimeter. If a given sample of aluminate requires, say 40 divisions, of test acid, to give it an acid reaction, the first 20 divisions ought not to produce any permanent precipitate in it : by this test the condition of the aluminate may be judged of. A greater portion of free alkali will not be injurious, but a smaller portion renders the mordant exceedingly irregular. Most salts precipitate alumina from the mordant ; muriate of ammonia is used as the chief agent for

fixing it upon cloth, salts of zinc have also been employed : the decomposition effected may be represented by the formula



the free ammonia passing into the liquor, alumina forming no combination with it.

IRON.

Iron is extensively employed for purposes in which it comes into contact with many chemical substances. The pure metal has no action upon most ordinary materials, but it is easily oxidised, and then it becomes chemically active, producing well-marked phenomena. The use of iron vessels for dyeing was long considered impossible, but it is now known to be the best material in all cases where no acid liquors are employed. Alkaline fluids have no action upon clean iron, but acids, even in a very diluted state, attack and dissolve it. It is evident, therefore, that iron vessels cannot be safely employed in any operation which requires the use of acids or acid salts, which term may be taken as including all the salts of the metals proper. Iron vessels cannot be safely used in colour mixing, or for storing colours, not even iron mordants ; but iron pans can be employed for alkaline colours, such as pencil blue or aluminate of potash. Wrought iron is with difficulty kept from rusting, on account of its lamellar structure ; cast iron is easily kept from rusting because of its homogeneity, and is to be preferred for the making of dye-becks and similar vessels. But cast iron soon rusts in the state in which it leaves the foundry. To prepare it for the purposes of the dyer the surface must be covered with some kind of protective coating. Ordinary paint would not answer well. Experience has shown that the best method of giving this protective coat is to boil water, containing some organic substance, in the iron vessels. Cow dung is most generally employed. Madder, logwood, and other colouring matters answer the same purpose. The effect seems to be that a combination between the firmly attached oxide and some of the principles of the organic substance employed is formed, which effectually cuts off any further action of the oxygen of the air, and of course any possibility of rusting. When, through long disuse, an iron beck has become rusty, it is necessary to scrape it well, and boil it for some time with cow dung or madder ; by so doing any free oxide is combined, and prevented from acting injuriously upon the subsequent materials used. Cast iron vessels used in bleaching are not considered safe unless the metal is covered with a film of lime or carbonate of lime ; this is readily accomplished.

in most cases, by scraping the metal and painting it over with milk of lime. The contact of cotton goods with rusting iron causes iron moulds, or stains, resulting from the partial fixing of the oxide of iron. A drop of strong hydro-chloric acid suffices to remove a single spot of iron mould, and may be applied to the cloth without injury to its strength.

Iron combines with oxygen in two proportions to form salifiable oxides ; the one called protoxide, the other peroxide of iron. There are, consequently, two series of salts of iron, which differ from each other so much in their properties that they might be salts of different metals. For the sake of brevity, the salts are called respectively proto and per-salts of iron. Sulphate of iron, or green copperas, is a proto-salt ; and commercial nitrate of iron is a per-salt ; by using dilute solutions of these two salts the most conspicuous characters of the two classes of iron compounds may be studied. Yellow prussiate gives a light blue precipitate with the sulphate of iron, but a dark blue with the nitrate ; the red prussiate of potash gives a dark blue precipitate with the sulphate, but no precipitate with the nitrate. Caustic soda produces a greenish olive precipitate with the sulphate, but a red precipitate with the nitrate. These are the respective oxides of iron. But the protoxide, when precipitated under favourable circumstances, is white ; it readily combines with more oxygen, changing to green, olive, and eventually to the well known rust-coloured oxide. When the buff colour from acetate or sulphate of iron is being raised in lime the protoxide is precipitated, and the cloth has only a greenish colour, but by exposing to the air, or acting upon it with oxidising agents, it absorbs oxygen, and becomes the buff peroxide. The proto-salts have a continual tendency to pass into the state of per-salts, absorbing the necessary oxygen from the air or other substances ; and there are cases, on the other hand, where the per-salts pass, by losing oxygen, into the state of proto-salts, but this is less usual than the contrary. The use of sulphate of iron in indigo dipping, and in China blues, depends upon the affinity of its oxide for more oxygen ; it deprives the indigo of oxygen, thus altering it, and putting it into a state favourable for solution. M. Kuhlmann has drawn attention to some cases of what he considers the oxidising effects of the peroxide upon calico. A rust spot is generally observed, upon dissolving the iron out, to be greatly weaker and thinner than the rest of the cloth. Calico strongly impregnated with buff is, upon the oxide of iron being removed, found to be more tender than is usual. These effects are attributed to an oxidation or slow combustion of the cloth, the oxide of iron acting as a carrier of oxygen to the organic matter. These points are of much importance in dyeing and printing, and deserve every attention.

Sulphate of Iron.—This salt has been used in dyeing from very early times, under the names of vitriol, green vitriol, and green copperas. It is a plentiful secondary product in some chemical manufactories: it is cheap, and not liable to be adulterated. It may contain salts of alumina and salts of copper to a limited extent, which would probably be prejudicial in some of its applications. A simple inspection is usually sufficient to know if a sample is good or not. It should not be wet or dirty; if dry, and with signs of rust, it is usually esteemed good because such appearances indicate an old-made and well-saturated copperas; but it is also possible for that character to be fraudulently given to it. Practical dyers form opinions from other appearances of the fitness of copperas for their uses, but it is doubtful if they are of any value. The points to be attended to in a chemical analysis are the acidity, which may be too great; the amount of water which it contains; and the absence or otherwise of alumina salts, which are liable to injure certain colours for which copperas is used. Copperas is much used in the dip blue and China blue styles, in dyeing black on cotton goods, and for numerous shades of grey, drab, and olive upon heavy cotton goods. It may be used for the preparation of acetate of iron by double decomposition. In calico printing it is very little used. Some receipts prescribe "calcined copperas," that is, sulphate of iron dried in an iron pan, and heated pretty strongly, with occasional stirring of the mass. It is possible by such means to convert simple copperas into a compound which may be called ferric bi-sulphate, having the formula $\text{Fe}_2\text{O}_3 \cdot 2\text{SO}_4$, although this does not take place wholly in the ordinary calcination; some approach is made to it. If sulphate of iron be calcined at a very strong heat, only peroxide of iron remains. A gallon of cold water can dissolve about four pounds of sulphate of iron, and it is much more soluble in boiling water.

Muriate of Iron.—A solution of iron in muriatic acid, marking about 80°, is sold under this name. It could be made by dissolving iron in hydro-chloric acid in a mug, or similar vessel, having an excess of the metal present. When the solution is concentrated by boiling, it deposits crystals of chloride of iron, resembling the sulphate in appearance, but much more oxidisable. The crystals are sometimes preferred to the solution, they are likely to be purer and more neutral. Muriate of iron is only sparingly used in printing and dyeing; it serves to obtain some shades of slate and drab by means of catechu for madder and garancine dyeing, and is used in a few combinations with salts of manganese.

Nitrate of Iron.—There is a nitrate of the protoxide of iron, but the

commercial nitrate of iron is always a per-salt. It is made by dissolving old iron hoops, or smithy scales, in moderately strong nitric acid. It requires some experience to make nitrate of iron successfully : if too much iron be added at once, if the liquid becomes heated, if the acid be too strong or not strong enough, there are a number of bye products formed, and sometimes the whole spoiled. The chief points are gradual addition of the metal in tolerably sized pieces, not to work upon more than a carboy of acid at once, and to have it so situated as to keep cool. Nitrate of iron is a dark red liquid, marking about 90° Tw. When diluted with water, it should remain clear without any addition, and should not give a blue precipitate with red prussiate of potash ; if the nitrate of iron is over saturated it becomes turbid upon dilution, some oxide or basic nitrate falling out, which may cause irregularity in dyeing ; if, on the contrary, it is too acid, it does not yield up its base in sufficient quantity or sufficiently rapid ; the addition of a little acid to the water in the first case, and some alkali in the second, will prove of advantage. Nitrate of iron is extensively used in dyeing and printing ; in the former it is the preferable iron mordant for all varieties of Prussian blue, and is used as the basis for black and grey. In calico and delaine printing it is used in a few steam and spirit colours. The only adulteration in nitrate of iron likely to occur is the substitution of hydro-chloric acid for a portion of nitric acid. All samples that I have tested contain some chloride, but not more than five per cent of the iron in solution should be allowed to be in this state. The perchloride of iron is not decomposable by fibrous matters to nearly the same extent as the per nitrate, and is consequently not worth so much.

Acetate of Iron.—An impure solution of acetate of iron is made by digesting metallic iron with crude pyroligneous acid for some weeks ; it has a black colour, and is known in trade as iron liquor and black liquor. The metal is in the state of protoxide, and though pure acetate of iron is easily oxidised, the organic matters, of a tarry nature, in the pyroligneous acid, effectually prevent any oxidation of it, as it exists in the ordinary iron mordant. Acetate of iron may be made by way of double decomposition between acetate of lime and sulphate of iron, and in times of pressure large quantities are thus made, though it is more expensive than the direct process. It is not necessary to decompose all the sulphate of iron by means of acetate of lime, from one-fourth to one-eighth may be left undecomposed without perceptibly injuring the mordant. The only practical test of the quality of iron liquor is to try it on cloth against a known quality. Its value depends upon the acetic

acid present rather than the iron, and its analysis is given under that acid. (See also Mordants.)

Alkaline Solutions of Iron.—There are some compounds of iron soluble in alkalies; they have been proposed as mordants and said to answer that purpose. I have tried them all, but found no good practical result. I believe they are not in use. The pyrophosphate of iron, formed by mixing a very neutral per-salt of iron with pyrophosphate of soda, is a white powder, insoluble in water but soluble in ammonia, forming a feeble mordant. M. Persoz states that this mordant will dye up colours in a bath of madder spent to ordinary mordants. I did not succeed in obtaining so desirable a result. Some arseniates of iron are soluble in alkalies, but do not yield anything of value as a mordant. Concentrated solutions of commercial nitrate of iron and carbonate of potash, when mixed, give a precipitate which re-dissolves in excess of the alkali, forming a clear dark red solution. This property of nitrate of iron was known to Scheele, and has been used in medicine, but not yet applied to dyeing or printing; it is a curious and unexplained reaction.

Ferric Acid.—Under certain circumstances iron assumes a superior degree of oxidation, and seems to act the part of an acid, forming highly-coloured compounds with alkalies. Ferric acid, to which the formula Fe O_3 is ascribed, has not yet been isolated; it is easily decomposed, and does not seem likely to have any applications at present.

CHAPTER XI.

MANGANESE—ZINC—CADMIUM—TIN.

MANGANESE.

THE metal manganese is obtained with difficulty, and is little known. In the state of black oxide of manganese it is an abundant natural product. There are two principal oxides of manganese, but only one of them forms compounds with acids in the general way, and that is the protoxide, formed of single atoms of the metal manganese and oxygen. It is this oxide which exists in all the commercial salts of manganese, and which is produced when caustic alkali is added to solutions of them. It is white at first, but soon undergoes a change from the absorption of oxygen; it assumes a reddish colour, which finally passes into brown, and in that state it is no longer protoxide, but either peroxide or a mixture of both oxides. The other oxide of manganese is the one found native, and which is extensively employed by chemical manufacturers in the preparation of bleaching powder; it is never employed in dyeing or printing, and does not call for any further special notice.

Sulphate of Manganese.—This substance can be prepared by heating the natural peroxide along with strong sulphuric acid. On the large scale this is done in reverberatory furnaces; on the small scale, it can be done in any vessel that will stand the heat and the acid. It requires a subsequent purification to free it from earthy matters and iron. It is not much used in dyeing or printing at present, although proved capable of several applications. It serves to prepare the other salts of manganese from, as the acetate, muriate, and nitrate. It can be used as the bronze liquor, for producing manganese browns, but it is generally the muriate of manganese which serves for this purpose; it receives an

application, in some places, for preparing cloth for indigo dipping, by which darker colours are obtained in shorter time than without. It has been recently patented as a substitute for sulphate of copper or blue stone, for resisting the indigo vat ; but, I am informed, there are great difficulties in the way of its application, and it is not in use.

Muriate of Manganese (Bronze Liquor).—This compound is a secondary product in the manufacture of bleaching powder. It is produced in very large quantities, so much greater than there is any demand for that it becomes a difficulty with some manufacturers how to dispose of it ; but if a recent plan for converting it into the peroxide is commercially successful, this will no longer be the case. It can be made tolerably pure from the sulphate of manganese, by means of muriate of lime. As usually sold it is in a liquid of a slightly pink colour, not likely to contain impurities, nor require any other test than the hydrometer. It is used for obtaining the manganese brown or bronze, by impregnating the cloth with it at a certain strength, and then passing in lime or ash. Like the iron buff, it must be well exposed to the air, in order to raise the colour, or else to some oxidising agent, as the chloride of lime. The first action is that the lime throws down the protoxide upon the cloth, and the second that this absorbs oxygen from the air, changes its colour, until it has absorbed all the oxygen it can, when it is in a state of peroxide, or near it.

Acetate of Manganese.—This salt can be made from the sulphate of manganese, by means of acetate of lead or lime. It is used for the same purposes as the muriate, and is preferred in many cases, as not liable to injure the cloth by an excess of acid. The acetate of manganese is used, mixed with other metallic solutions, to produce various shades of colour.

When the oxides of manganese are heated with alkalis in a manner favourable to oxidation, they absorb more oxygen, and form compounds with them, called manganates and permanganates. These compounds have rich colours, which, however, are easily destroyed by any substance which can take oxygen from them. A piece of calico dipped in a clear solution of permanganate of potash soon decolorizes it, while it gets permanently impregnated with the oxide of manganese. Deep and full shades of brown may be thus obtained, and are actually so produced upon silk and woollen, but, as these fabrics must be oxidised in the process, it would be interesting to know whether there is not a deterioration of their strength. The permanganate of potash has been employed to mark calico, but it will not resist acid treatments. Since the permanganate is reduced by all the vegetable thickenings, it can

only be applied as a topical colour, by being thickened with pipeclay, or some similar non-oxidisable substance.

ZINC.

The metal zinc is but little employed in dyeing or printing operations. It is not, like iron, actively injurious to colours or mordants, but it is rapidly corroded under the influence of acids or alkalies, vessels made of it wearing out in a short time. Zinc combines with oxygen to form a white oxide, which is of a brilliant lustre; it has been used as a pigment colour in calico printing, being fixed by albumen. The oxide of zinc, made by burning, is the most suitable for this purpose; that which is produced by precipitation being defective in softness and lustre, probably owing to a different molecular arrangement. Oxide of zinc is soluble in ammonia, and nearly all the acids, yielding colourless salts, unless the acid be coloured. The only zinc salts used in dyeing or printing are the sulphate, chloride, and acetate.

Sulphate of Zinc, or white vitriol, can be prepared by dissolving zinc scraps in weak oil of vitriol. As zinc mostly contains a small quantity of iron, it should be removed from the solution. This is done by adding a quantity of a mixture of chemic (chloride of lime) and water to the liquor when it is saturated with the metal; this mixture oxidises the iron, and throws it down at the same time as an ochry powder. Pure sulphate of zinc gives only a white precipitate with yellow prussiate, and when mixed with strong ammonia gives a precipitate at first, which dissolves when sufficient ammonia is added. It is especially when sulphate of zinc is to be used for adding to red liquor mordants, or for mixing with the dung in cleansing or fixing alkaline pinks, that it should be free from iron. Sulphate of zinc serves as a resist in several styles, and is a constituent in what is termed "mild paste." A new use of sulphate of zinc has been proposed by Balard and Sacc, by which, if it turn out successful, this salt may be employed instead of tartaric acid for discharge upon dyed grounds. They have found that if sulphate of zinc be mixed in certain proportions with solution of bleaching powder, it increases its power in about the same way as if acid was added; and they have found that if dyed cloth (Turkey red for example) be printed with sulphate of zinc, and passed into bleaching powder, it discharges the colour wherever the zinc salt was printed. The applications of this discovery have yet to be made upon the large scale, and it remains to be seen whether it will prove economical or practicable.

Chloride of Zinc (Muriate of Zinc).—This salt is easily obtained by dissolving metallic zinc in spirits of salts. It is not much used either in dyeing or printing. It is employed to fix the alumina of the alkaline pink mordant, and is added to some colours to keep them moist or soft. The muriate of zinc having a great tendency to attract moisture from the air.

Nitrate of Zinc has been employed for the same purpose as the muriate of zinc, and especially in the case of red liquor pinks. It is made by dissolving the metal in weak aquafortis.

Acetate of Zinc.—This salt is very little used. It may be made by dissolving the oxide of zinc in acetic acid, or from the sulphate of zinc by means of acetate of lead. It gives a beautiful orange yellow on silk and cotton with murexide.

Zinc yields no colours except the white from the oxide ; it does not form coloured compounds, and it has hardly any affinity for either vegetable or animal fibre.

Cadmium.—Cadmium is a metal having resemblance to zinc. It is very rare, and consequently expensive ; it does give some coloured compounds, which, if they were not too expensive, might receive application in dyeing and printing. The compound of sulphur and cadmium has a fine orange yellow colour.

TIN.

Tin is a very important metal to the dyer and printer from the affinity which it shows both for fibres and colours, and the brilliancy of the shades it gives. As a metal its expense prevents it being much used in the way of vessels or utensils, what is commonly called tin being only iron coated with tin. Tin vessels are usually distinguished as of block tin. It is used, however, in some dye houses, especially where scarlets from cochineal or lac dye are dyed. It is found that copper does very well, except where the air comes in contact with the liquor. and I believe the pans are made of copper at the bottom to stand the fire, and of block tin on the upper part where the air acts, and where the pieces would come in contact with the bare metal. For experimental purposes of dyeing, and especially for mordanting in tin solutions with heat, block tin vessels are by far the best. Tin melts at a low heat, and consequently vessels made of it must never be exposed to fierce fires. Tin combines with oxygen in two proportions, forming the protoxide, which has one atom of tin to one atom of oxygen, and the bioxide or peroxide, which has two atoms of oxygen to one of tin :

this last, from its sometimes acting the part of an acid, is called also stannic acid, the Latin name for tin being stannum. Tin in the metallic state is used in preparing one colour for printing, that is, a kind of indigo blue, called "fast blue." The tin for this purpose, and for all purposes of dissolving, is first granulated by pouring it from a height when melted, into cold water ; in this case the granulated tin is boiled with caustic soda and the powdered indigo, the metal takes oxygen from the indigo under the influence of the alkali, and the colouring matter is thus brought into solution ; the same, or an equally good colour, can be prepared in other and better manners. The protoxide of tin, like many other protoxides, has an affinity for more oxygen to change itself into the peroxide, and it will take this oxygen, under favourable circumstances, from bodies put into contact with it ; it is this property which enables it to dissolve indigo when mixed with caustic alkalies. The protoxide may be made by adding the proper quantity of caustic soda to solution of crystals of tin ; too much caustic will re-dissolve the oxide ; it falls down as a white pulp, which can be drained and washed on a filter. It is not necessary to separate the oxide of tin from the liquor for most practical purposes, and the necessary quantity of indigo, caustic, and tin solution are mixed and all heated up together. The peroxide of tin has no inclination to take any more oxygen than it already possesses, and cannot aid in the solution of indigo. Both of these oxides combine with acids and they have different properties, though both answer nearly equally well as mordants.

Chloride of Tin, Muriate of Tin, Crystals of Tin.—The crystals of tin are a compound of chlorine, tin and water ; they are made by dissolving tin, by means of heat, in spirits of salts, boiling down and crystallising. They are supplied by respectable chemical manufacturers in a state of almost chemical purity, but they are said to be sometimes adulterated with zinc. I doubt this with regard to the crystals. I never found any such adulteration, and I think it would spoil the appearance of the crystals so much as to make it apparent to any one that something was wrong. The crystals may be bad by age and by being too wet, and their appearance shows this ; they should be clean and glistening, slippery and greasy feeling to the finger, and have no white powder or white slime about them. When a couple of ounces are mixed with a gill of common water the liquor should be clear, but when the same weight is mixed with a gallon of water, the liquor ought to become white with a white sediment forming ; this test shows in the first case that they are acid enough, and in the second that they are not too acid.

Crystals of tin are largely employed in dyeing and printing; in dyeing as a mordant, in printing as helping to form colours and to communicate to them peculiar properties, as, for example, mixed with strong red liquor, it enables the red mordant to resist light covers of chocolate or purple mordants; it acts as a discharge on some colours, as iron buff, manganese browns, &c., and has many other uses.

Liquid Muriate of Tin.—This compound is chemically the same as the crystals of tin, and is made in the same manner, except that it is not boiled down to the crystallising point. It is decidedly more acid in its behaviour than the crystals, and herein lies the only difference, if the liquid muriate is a genuine article. Weight for weight it is not much more than one half of the strength in tin of the crystals. It is liable to be adulterated with several cheaper solutions, and I do not know any good practical test, except trying it in colours against a sample of known goodness. By chemical analysis it is easy to ascertain its exact value. It is used in dyeing for much the same purposes as the crystals, in colour mixing also; this is the salt mostly used for preparing tin pulp or prussiate of tin for steam blues.

Sulphate of Tin is hardly at all used in dyeing as a pure salt, but there are cases in which a mixture of vitriol and crystals of tin is employed, and probably sulphate of tin is formed here; but the process never goes to the extent of driving off the muriatic acid, so it is not certain what the resulting product is, probably a sulphate of tin kept in solution by the muriatic acid. Sulphate of tin itself is not easily made, and is too expensive for general use. It can be made by stirring up granulated tin in water with sulphate of copper; the copper falls down, and the tin takes its place with the sulphuric acid. There are solutions of tin made by dissolving the metal in mixtures of vitriol, water, and common salt, or, instead of common salt, sal-ammoniac, sometimes spirits of salts and vitriol; there is very likely formation of sulphate of tin in these cases. When strong sulphuric acid acts upon tin with the assistance of heat, various gases are evolved, and a compound of the peroxide is left, which requires a good excess of acid to keep it in solution; I have found no protoxide salt even when a good deal of the metal has been left unacted upon.

Bi-chloride of Tin; Double Muriate of Tin.—This differs from common muriate of tin by having the metal in the higher state of oxidation; it requires a special method of preparing, and possesses quite different properties from the muriate. When a few drops of this bi-chloride of tin are mixed with a solution of bi-chrome, it ought not to change the red colour to green, which it will if it is not well made, or if

it contains any of the common muriate. The bi-chloride of tin is not largely used either in dyeing or printing. It serves as a prepare for woollens and delaines to make them take colours better in printing; it is for this purpose mostly mixed with some of the common muriate, and is an ingredient in some colours and in some dyes. It can be made by dissolving grain tin in a mixture of two parts spirits of salts, one part aquafortis, and one part water, till no more dissolves.

Oxymuriate of Tin (Proto-per Chloride of Tin).—This liquor is made in general by dissolving granulated or block tin by degrees, in a mixture of nitric and muriatic acids; it is for the most part a bi-chloride of tin, but frequently containing some of the proto-chloride or common muriate; it is generally well saturated, that is, with little excess of acid. It is also generally of a milky appearance, from a quantity of undissolved oxide of tin held in suspension. It can be made from the common muriate of tin, or from the crystals, by heating them in a mug, and adding strong aquafortis by degrees, so long as red nitrous fumes are given off. It is extensively used in making spirit colours by calico printers; it is employed in Turkey red and madder pink dyeing, to reduce the shade to a bluer tone, and in several cases of dyeing.

Dyers' Spirits.—These are solutions of tin in endless variety, and with hundreds of modifications; every dyer or maker thinks he has the best method of preparing the spirits, and usually guards his secret as valuable. They are all of them a mixture of proto-chloride and perchloride of tin, some with sulphuric acid; nitric acid almost always enters as a constituent, but is doubtless all destroyed in the oxidation of the tin. Common salt, sal ammoniac, saltpetre, nitrate of soda, and other salts, are used in conjunction with the acids, and possibly modify the product, so as to make it better adapted to the peculiar office it has to fulfil; more frequently these additions are the effects of caprice, and the advantages they confer entirely imaginary.

Stannate of Soda (Preparing Salts).—This salt is compounded of the peroxide of tin, mentioned above, and caustic soda; its value and its applications depend upon its giving up the stannic acid, or peroxide, when an acid is mixed with it. The method of preparing pieces with it, either for printing or dyeing, is to pad them in a solution of it, and then pass them into sours; the sulphuric acid takes the soda, forming sulphate of soda, while the stannic acid remains attached to the cloth. The value of the preparing salt depends upon the quantity of tin which it contains, which quantity can only be ascertained by means of analysis. A practical test is to prepare fents with it against other fents prepared

with a salt of known quality. The strength of the hydrometer, which a certain quantity gives to a gallon of water, is little or no test. I had occasion to analyse a sample of preparing salt said to be of double strength; it only contained as much tin as the regular quality, but it had about twenty-eight per cent of common salt in it, and was quite dry, whereas the ordinary good stannate has from twenty-five to thirty per cent of water in it, and no common salt; the sample, which was of double strength, and was to be charged considerably higher, had been made by driving the water away from the ordinary quality, and putting salt instead; one pound of it in a gallon of water stood several degrees higher than a pound of the common stannate—and this was the test the manufacturer desired to be applied—but chemical analysis demonstrated that it was not worth any more than the stannate with water, and was likely to be worth much less, as so great a quantity of useless substance might impede the fixation of the tin upon the cloth. Some very good preparing salts contain a portion of arsenic, in the state of arsenic acid combined with soda, and the makers consider it as important in yielding good results. It appears to combine with the tin, and fix with it upon the cloth. I have made experiments with preparing salts with and without arsenic in them, and, if the conditions were otherwise equal, I could never find that arsenic was an improvement. I consider that the good quality of these salts is attributable to the care exercised in their manufacture, and not in any manner to the arsenic present; at the same time it should be understood that, while in some cases a certain ingredient seems unnecessary and useless, it acts an essential part in other cases, where perhaps the general conditions are not so favourable, or, at any rate, not the same.

Acetate of Tin, prepared by mixing solution of crystals of tin and acetate of soda, or acetate of lime, has been used to a limited extent as a mordant. It has been employed to obtain an orange in garancine work, by using Persian berries in the dye; but the colour is subject to some uncertainties, and interferes with obtaining other colours in a satisfactory state; it is also very loose, and this is the case, generally speaking, with oxide of tin as a mordant on vegetable fibre.

Analysis of Tin Salts.—The value of tin salts, whether acid or alkaline, depends upon the amount of metal in them; they are liable to sophistication, and require to be occasionally tested. In simple solutions of tin the metal can be determined by evaporating to dryness with some nitric acid; bi-oxide of tin will be formed, which, if the heat has been carried far enough, is insoluble in water, and after being washed, may be weighed as such.

There is a rapid volumetric method of estimating the value of tin salts, first published, I believe, by Dr. Penny. It is applicable to salts of the protoxide only, and depends upon their power of deoxidising chromic acid : $2 \text{Cr O}_3 + 3 \text{Sn O} = \text{Cr}_2 \text{O}_3 + 3 \text{Sn O}_2$. Solutions of chromic acid have a well defined red colour, while those of chromic oxide are green, and it is the change of the red colour into green which indicates the completion of the reaction ; every two atoms of chromic acid require three atoms of tin in the state of protoxide, to destroy its characteristic colour. It is, therefore, possible to ascertain how much metal there is in any given solution, by knowing how much chromic acid it can destroy. This method is applicable to tin in the lower state of oxidation only, but the salts of the higher oxides and the stannates can be brought within its range, by first reducing their tin oxide to the state of protoxide. This is done in the case of the acid salts by adding slips of sheet zinc to the weighed portion ; it precipitates the tin in the metallic state, which, being re-dissolved again by boiling hydrochloric acid, will be in the right state for testing. The alkaline stannates require to be super-saturated with acid before the zinc is added to reduce them.

Dr. Penny found that 83.2 grains of pure bi-chromate of potash were deoxidised by 100 grains of pure tin when dissolved in acid. The standard liquors are made in accordance with these numbers. 83.2 grains of bi-chromate are dissolved for every thousand grains of water, and each division, or ten grains, used in testing a solution of tin salt indicates one grain of metal. The solution of tin brought to the state of protosalt, is diluted with a rather large quantity of water strongly acidified with hydro-chloric acid, and the bi-chromate test liquor added from a burette so long as its red colour is destroyed. The exact point is easy to perceive, but not possible to indicate in writing. It is sufficient to say that the solution will have a bright blueish green so long as it does not contain any undecomposed chromic acid, but that a very small excess of the test liquor gives it an olive shade. A few trials will make anyone acquainted with the stopping point, and render unnecessary any testing of the fluids.

Here are the results of some determinations of the amount of metal in various tin salts used in printing and dyeing, which the author has had occasion to make, premising, that, with regard to stannate of soda there is no fixed standard of quality. Respectable manufacturers, when not confined to price, supply it with about 20 per cent of metallic tin ; but, to meet competition, and to adapt themselves to the demands of

ill-informed purchasers, they graduate it with common salt, so as to contain 15, 12½, or only 10 per cent of tin :—

Cryst. Proto-chloride of Tin No. 47=51 per cent metal—rather moist sample.

Cryst. Proto-chloride of Tin No. 19=52 per cent metal—good.

Cryst. Proto-chloride of Tin No. 63=52 per cent metal—good.

Cryst. Proto-chloride of Tin No. 89=51 per cent metal—rather weak.

The theoretical quantity of tin, according to the formula $\text{Sn Cl} + 2 \text{HO}$, is
52.3 per cent.

Oxymuriate of Tin, at 120° Twaddle=18.6 per cent of bi-oxide of tin.

Bi-chloride of Tin (Double Muriate)=19.0 per cent of metallic tin.

Liq. Muriate of Tin, at 118° Twaddle=29.5 per cent of metallic tin.

Liq. Muriate of Tin, at 116° Twaddle=28.0 per cent of metallic tin.

Stannate of Soda, solid, No. 57=19.5 per cent metallic tin.

Stannate of Soda, solid, No. 19=15.5 per cent metallic tin.—Sold as such.

Stannate of Soda, solid, No. 7=19.5 per cent metallic tin.

Stannate of Soda, solid, No. 35=20.4 per cent metallic tin.

These determinations are of good qualities of the respective salts, and may be taken as standards for comparison.

CHAPTER XII.

ARSENIC—CHROMIUM—ANTIMONY—BISMUTH.

Arsenic.—Metallic arsenic is not used in dyeing or printing. The white powder which goes by the name of arsenic, and which will be called arsenic in this work, is actually an oxide of arsenic, the chemical name of which is arsenious acid. The real metallic arsenic is black, and has a metallic lustre; it is said not to be poisonous, while the oxide is the well-known virulent poison.

Arsenious Acid, or White Arsenic, is too much used, especially in calico printing. So deadly a poison is not safe in the hands of men who always use it incautiously, and who may have temptations to apply it improperly; but, as there is nothing which can replace it in a few cases, it is incumbent on the principals of those houses where it is employed to see that it is in the charge of some trusty person, and that it passes through as few hands as possible before it is applied to its intended use. This remark applies as well to the red arsenic as to the white.

White arsenic is used for several purposes; combined with soda, as arsenite of soda, it forms a dung substitute, which gives good results when properly made; it enters into the composition of an ageing liquor, as mentioned under chlorine; it is employed as a reducing or de-oxidising agent in preparing colours from bi-chromate of potash; it is, by continental printers, put into iron liquor mordants, under the impression that it improves them; and it forms a part of the preparing salt, stannate of soda. There is another compound of arsenic with oxygen, containing more oxygen in proportion to the metal—it is an acid, and is called arsenic acid; it can be made by heating the white arsenic with aquafortis in a proper vessel, the arsenious acid absorbs oxygen from the nitric acid, and becomes arsenic acid. Arsenic acid differs from arsenious

acid in many respects : it is very soluble in water ; arsenious acid dissolves in only small quantities, in water ; it is a strong acid, while arsenious acid is not acid to the taste, and, under any circumstances, is one of the weakest acids ; it forms well defined crystallisable salts, while arsenious acid does not. The arsenic acid has been proposed as a cheap substitute for tartaric acid in dyeing and printing, but the attempts to apply it have not been very successful. It is sometimes used as a discharge and resist. In a state of combination with soda, called arseniate of soda, it is largely used as a dung substitute, and under proper management can be made to answer well enough.

Orpiment (red sulphuret of arsenic).—Orpiment is a compound of sulphur and metallic arsenic ; it has a good yellow colour, and has been used to some extent as a colouring matter. It was applied to cloth by dissolving it in ammonia ; padding the cloth in this clear liquor, and then hanging up till the ammonia evaporated, and left the orpiment fixed to the fibre. Its principal use in calico printing is as a reducing agent ; for, when mixed with caustic soda, or potash, it has a strong affinity for oxygen, and will take it from many substances—among others from indigo. It is used in this way in preparing the blue known as pencil-blue, and which, in later days, was tried to be applied as “gas blue,” but without success. Orpiment is a component in many of the receipts for China blue, and it appears to fulfil some useful part in it, although China blue can be obtained without it.

Orpiment is poisonous, but not to the same extent as white arsenic or arsenic acid. It may not be out of place to state here that one of the best antidotes for arsenic is the hydrated peroxide of iron, which can be readily made on the works where the arsenic is used, by mixing about a noggin of strong nitrate of iron in a quart of water, and adding to it soda crystals dissolved in water, until all the acid is neutralised, and there is an abundant ochry-coloured deposit. This deposit is the antidote. It should be drained from the top liquor, and administered wet. If it does not settle out quickly, or the case is urgent, the mixture may be administered just as it is made. It is not to be trusted much. In all cases of poisoning competent medical assistance should be obtained as soon as possible.

CHROMIUM.

Chromium, the metallic base of all chrome salts, is a metal, but so difficult to extract, that its properties are almost unknown, it being even a question whether the pure metal has ever been extracted

Chromium exists in the earth combined with iron, as the common chrome iron ore, also combined with lead in some parts, as chromate of lead. There are two compounds of this metal with oxygen, probably more, but only two which are of any practical importance at present. One of these, containing the lesser quantity of oxygen, is the oxide of chromium; the other, containing twice as much oxygen, is an acid, and called chromic acid.

Oxide of Chromium is green, and can be prepared in various ways. A good way is to mix powdered bi-chrome with dry powdered starch, and calcine the mixture at a red heat, in an earthen crucible; when cold, wash it with warm water, which removes the potash and leaves the green oxide insoluble in water. A method of obtaining this oxide of a very fine green colour, suitable for calico printing purposes, has been recently patented in this country and France; the bi-chromate is calcined in a furnace along with boracic acid, many precautions being necessary in order to produce the best result. In consequence either of the expense of the boracic acid, the difficulty of the process, or something else, the price of this green pigment is too high to render it extensively applicable, the more so as it requires the use of albumen to fix it; it is, however, a good deal used in first class muslin printing. The greyish green colour, known as Victoria green, &c., obtained from printing the sulphate of chromium upon cloth, or raising in lime, is due to the oxide of chromium. The colour of this oxide is subject to some extraordinary and inexplicable changes in the moist state—sometimes it is green, sometimes grey, occasionally pink or peach coloured, at other times nearly violet. It is not known what these different hues are owing to; up to this time no one has succeeded in getting anything like a good bright green oxide from chrome by the moist way. The best results I have obtained in experiments have been when the yellow chrome has been reduced upon the cloth by powerful deoxidising agents.

.. *Sulphate of Chromium*, for colour-mixing purposes, is made by mixing strong vitriol with a hot solution of bi-chrome, and adding sugar to it until all the action is over, and the liquor is of a clear grass green. During this process much gas comes off, having a peculiar smell; heat is developed, and, unless the operation is cautiously conducted, the liquor will boil over. The use of the sugar is to take the extra portion of oxygen from the chromic acid, and bring it into the state of oxide of chromium, which is dissolved by the acid. Other substances would do instead of sugar, which are of the same nature; in the laboratory spirits of wine and wood naphtha would be preferred as cleaner, but of course more expensive. The sulphate of chromium thus made serves to give the Victoria green

spoken of; sometimes it does not require thickening, at others it does. It is difficult to thicken, coagulating the natural gums; it can only be well thickened by manufactured gums, and of those the most soluble must be used. The colour sometimes does not coagulate until it is deposited on the cloth, and then the chromium does not penetrate the fibre, and, upon raising, it nearly all comes off. If such an accident happen, the thickening will have to be changed, and probably a little more acid employed in making the liquor.

Another kind of chrome green is made by reducing the bi-chrome with white arsenic: the arsenious acid takes up oxygen from the bi-chrome, and becomes converted into arsenic acid, which in its turn combines with the oxide of chromium and forms arseniate of chromium, which deposits as an insoluble powder; this is dissolved in a mixture of nitric and acetic acids, thickened, printed, and raised, as in the case of sulphate of chromium; its shade can be modified by the addition of other metallic salts, as salts of manganese and iron. It is a very dangerous, poisonous colour to make up, and the sooner it is banished from the colour mixers' list the better for all parties; these arsenical colours mostly come to us from Bohemia, where arsenic is cheap and abundant. They are always dangerous; the arsenic in this case goes on the cloth, to be worn perhaps by children, and some of it imbibed by them, producing diseases whose origin is little suspected.

Chloride of Chromium can be made in the same way as the sulphate, substituting muriatic acid for vitriol; it can be used for the same purposes, and yields as nearly as possible the same results.

Chrome Alum.—This is a compound of sulphate of chromium and sulphate of potash. It is called an alum because it is similar in crystalline and chemical constitution to regular alum, but it contains no alumina. It cannot be used with advantage instead of the simple salts of chromium, not being sufficiently soluble to yield good results. From it, by mixing with acetate of lead, can be obtained an acetate of chromium, which has not yet received any regular employment either in dyeing or printing, but which, from its character, seems likely, at some time or other, to be of value in these arts. Oxide of chromium is a feeble, inefficient mordant; it does exercise an attraction for colouring matters, but it is weak, and its compounds have neither brilliancy nor stability. A kind of light pink can be obtained from madder by means of tartrate of chromium, but it is not so good as an alumina pink, and more expensive.

Chromic Acid.—By making a solution of bi-chromate of potash in cold water, as strong as possible, and adding twice the bulk of refined

oil of vitriol, there are produced, upon the cooling of the liquor, crystals of a fine red colour, which, when separated from adhering impurities, are chromic acid. The acid itself is not employed for any purpose in dyeing or printing, but its compounds, with potash or soda, are extensively used.

Yellow Chromate of Potash is a compound of one atom of chromic acid and one atom of potash; it is not much used.

Red Chromate of Potash, Bi-chromate of Potash, or Bi-chrome, is a compound of two atoms of acid with one of potash, and, as it is the chromic acid which gives the value to these salts, it is worth proportionably more than the yellow chromate. It is made from the yellow chromate by the addition of vitriol. Two parts of yellow chrome, when acted upon by one part of sulphuric acid, yield one part of sulphate of potash and one of bi-chrome; the acid taking away part of the potash, the remaining potash has double the quantity of chromic acid: *vice versa*, the addition of caustic potash to bi-chrome brings it back again to the state of yellow chrome, as can be easily seen by the change of colour produced in mixing them. Bi-chrome is not nearly so soluble in water as the yellow chrome, but it is very much more active, and its activity is still further increased by being mixed with a little acid. It has many uses in dyeing and printing, among which may be mentioned the raising of chrome oranges, the preparation of chrome shades just mentioned, the fixing of catechu, and raising steam blues and greens. Several of the uses of bi-chrome depend upon its oxidising character. It is ready to part with a portion of its oxygen to many colouring matters; this is the foundation of its employment in raising steam blues,—it gives oxygen to the palish blue, and heightens its colour; but care must be taken not to use it too freely, for in that case it injures the colour and the white, probably owing to the formation of some compound of chromic acid with oxide of chromium which fixes itself over the piece. With catechu colours it oxidises them, and generally a small quantity of the oxide of chromium produced remains in a state of combination with the colouring matter. Another use of bi-chrome is in discharging indigo blue; this is also a case of oxidation, but what may be called destructive oxidation; by the contact of the bi-chrome and the acid the chromic acid is set free, and it immediately parts with oxygen to the indigo, and converts it into a colourless body, which can be washed away. If precautions are not taken, the bi-chromate is likely to act upon the cloth itself, injuring or destroying its texture.

The quality of bi-chrome salt may be judged of in a great measure by simple inspection; if it is in good solid crystals of a uniform red

colour, and without admixture of soft yellowish crystals, it may be considered as good ; if, however, it is not of this character it may still be good, but it is open to suspicion, and should be analysed. The chrome salts, which are of a yellow colour, and not in well defined crystals, cannot be judged of correctly by mere inspection ; their composition is variable, sometimes much stronger than at others, but all the samples that I have had occasion to test were, with regard to their proportion of chromic acid, decidedly inferior to bi-chrome, and much more expensive than it, taking into account the relative prices and qualities of the two substances. The manufacturer can be certain of his bi-chromate if he only insists on having it in good-sized, clean, dry crystals, of the proper colour ; but he can never be certain of the compound sold as chrome salts.

Analysis.—The commercial value of the chromates can be determined by the reaction used in determining the value of tin salts. Taking, in this case, some tin salts of known purity, or, what is better, dissolving a known weight of pure metallic tin, and ascertaining how much of a given sample of the chromate it takes to peroxidise it—the change of colour indicating the termination of the action. Another, and more accurate, though longer method, is to reduce the chromic acid, by alcohol and hydro-chloric acid, into a salt of sesquioxide, precipitate by ammonia, and determine the chromic acid from the weight of oxide of chromium thus obtained. I give here a few results I have obtained in the examination of various samples of chrome salts :—

Sample, Yellow Chrome Salts, contain 37.0 per cent chromic acid.			
"	Chromate of Soda,	28.0	" "
"	Yellow Chrome Salts,	28.5	" "
"	Bi-chromate of Potash, good	61.0	" "
"	Bi-chromate mixed with Yellow Crystals	54.0	" "

The theoretical quantity of chromic acid in pure bi-chromate is about sixty-two per cent, and the commercial samples will give nearly that result when good. The price of the yellow chrome salts tested above was much less than that of the bi-chromate, but, calculated for the quantity of chromic acid, they were about twenty per cent dearer.

Metallic tin is the best source of the test liquor, but it has the inconvenience of dissolving very slowly, even in the strongest hydro-chloric acid. If crystals of chloride of tin, of a good quality, are melted at a gentle heat, and allowed to solidify in a deep vessel, I find they will keep good for a long time, and give uniform results ; this is not the case with the feathery crystals, which absorb oxygen, and cease to dissolve

completely in water after a few weeks. Diluted solutions of protochloride of tin are injured in less than a week, so that it is always necessary to have a fresh solution of tin for every series of experiments.

VANADIUM, MOLYBDENUM, TUNGSTEN, COLUMBIUM, NIOBIUM, ANTIMONY, URANIUM, TITANIUM, TELLURIUM, BISMUTH.

These are names of metallic substances, which, if this were a work of general chemistry, would be fully treated of in this part, but require only a brief mention here.

Vanadium is said to have some resemblances in its compounds to the compounds of chromium, and hopes are entertained that if ever a plentiful supply of this metal or its ore can be obtained, it will be of some use in printing and dyeing. The late Dr. Ure stated that an ink could be prepared from it of very superior colour and durability. It is exceedingly rare under any form, and only kept as a chemical or mineralogical specimen.

Tungsten.—The ore of this metal exists in tolerably large quantities in Cornwall in conjunction with tin ore. All through its compounds it has a resemblance to tin. Some years ago tungstate of soda was sent into commerce to be used as a substitute for stannate of soda, but it would not answer, and all attempts to apply it as a mordant for colours failed. Some of the compounds of tungsten have good colours, but they vanish in trying to fix them. If some tungstate of soda be put into a vessel, an excess of muriatic acid added, and then some slips of thin zinc, a fine blue powder will be formed in a short time, the composition of which is not very well known. If this be collected on a filter and washed it soon loses colour, and in a few hours will be nearly white. Many attempts which I made to put this blue compound into something like an inactive state, or to produce it upon the cloth itself, were without any practical result. It appears from all my trials that tungsten would be of no use in dyeing or printing, however cheap or plentiful it might be.

Antimony.—This metal is tolerably plentiful, and many years ago it was a constituent of an orange colour used pretty largely in dyeing and printing, but now it is hardly ever employed. Antimony has some analogy to tin in many respects, and fancying that it might produce something worth having as a mordant or a prepare, I tried most of its compounds, both alkaline and acid, and came to the conclusion that it was inferior to tin; at the same time it did partially act as mordant,

and in preparing cloth it gave better colours than without prepare, but decidedly inferior to tin. It was the sulphuret of antimony which was formerly employed as a colour; it was dissolved in caustic alkalies, and after printing fixed by passing through weak sours. It was then an orange, and by passing it into solutions of copper and lead, the shade could be varied in several ways. The colours thus made were not very good, either as to brilliancy or fastness; they are not, I believe, known practically in the trade at all now, as similar and better shades are obtained by other processes.

Uranium.—This is a rare and expensive metal; it has no applications as yet, but it can act as a mordant for some colours, having a resemblance in its chemical properties to iron, but whether these colours are any good for practical application remains to be seen.

Bismuth is a metal known in print works as forming part of the composition of an alloy used in making a kind of block or stereotype plate for printing with. It is not used for anything else, its chemical characters not making it of any value as a colouring matter; the oxide or subnitrate of bismuth can act as a mordant for garancine and madder, but the colours it gives are dull and absorbent and of no value in the trade.

CHAPTER XIII.

COPPER — SULPHATE OF COPPER — CHLORIDE OF COPPER — NITRATE OF
COPPER — ACETATE OF COPPER — AMMONIURET OF COPPER — ARSENITE
OF COPPER — FATTY SALTS OF COPPER — NICKEL — COBALT.

COPPER.

THIS metal is the best for small vessels employed in holding or measuring chemical substances; it is less easily acted upon by acids than iron; it is harder and stronger than tin, and more economical, because requiring less weight and enduring longer. Pure clean copper is not acted upon in the cold by muriatic or sulphuric acids; if the copper is tarnished, either of these act upon it in so far as to dissolve the oxide which tarnishes the metal, but they do not touch the metal itself. If exposed to the action of the air and acids simultaneously, the copper is rapidly corroded. Copper pans or boilers which are accustomed to hold acid liquors, are more strongly corroded above the water mark than below it, and if the level of the contained liquor is pretty constant, the corrosion is most active at or slightly above the water mark. This is owing to a natural chemical law, several times alluded to already, that a metal must be oxidised before it can dissolve in an acid; some metals take oxygen from the acids themselves, or from the water in them, but this is not the case with copper and the two acids mentioned. It must obtain the oxygen from some other source, and that source is the air. Copper is not hurtful to most colours, as iron is; many colours are improved by it, and but few really injured. Notwithstanding this, it is not wise to leave colours in copper vessels longer than necessary, especially steam and spirit colours which contain acid salts; the copper dissolved, though little, alters delicate shades, and frequently puzzles the colour mixer.

Nitric acid, or aquafortis, acts rapidly on copper, hot or cold, itself supplying the oxygen necessary to the solution of the metal. Liquid ammonia in contact with the air acts on copper, dissolving it and becoming blue; it should not, therefore, be kept, or even measured in copper vessels. Colours which are alkaline with ammonia should not be allowed to remain in copper vessels, nor be worked in the printing machine out of copper boxes. Liquids which contain sulphur in alkaline solution also act upon copper, turning it quite black and corroding it, although not to a very perceptible extent; the black body produced is a sulphuret of copper, and if kept exposed to the air and moisture, it eventually changes into sulphate of copper, or bluestone. But, in dry situations, the sulphuret remains unaltered for a long time: for example, copper rollers blackened in the machine by using pencil blue or impure alkaline pink.

Copper combines with oxygen in two proportions, forming the red or sub-oxide, that is, an oxide with less than an equal atom of oxygen, and the black oxide, which contains an atom of oxygen for an atom of copper. Neither oxides are ordinary commercial articles, nor used in dyeing or printing; but the sub-oxide yields a colour which may be produced by printing acetate of copper, raising in lime or soda, and then boiling in a strong caustic ash, mixed with sugar, treacle, or calcined farina, until it has changed into a yellowish orange; I am not aware that this colour is worked anywhere at present. The sub-oxide in this state can act as a mordant, but it does not give bright or fast colours with any of the dyewoods I tried. The production of the sub-oxide above from the black oxide, is owing to the reducing or deoxidising power of the alkali and organic matter. The black oxide is used to make the salts of copper from. The salts of this oxide have all a green or blue colour in the hydrated state, but when deprived of water are often colourless. They have a feeble oxidising power, which acts under favourable circumstances upon many organic substances. It would appear that a given portion of copper salt is able to oxidise an infinite amount of some organic substances under favourable conditions: it is supposed to act first by giving up the half of the oxygen in its oxide, and the sub-oxide formed absorbs oxygen from the air, transferring it to the oxidisable substance *ad infinitum*. It is as oxidising agents that copper salts are used in most cases of dyeing and printing.

Sulphate of Copper, Blue Vitriol, Blue Stone.—This is a compound of vitriol, the black oxide of copper, and water. It is used to make the acetate and nitrate of copper from, by means of the acetate and nitrate of lead; it is employed in a few cases of colour mixing

and dyeing, but altogether only a small quantity is consumed in these arts, as the acetate and nitrate of copper are mostly purchased from the manufacturers. The greatest quantity is used by the indigo dyers, as a resist, in combination with other matters.

Chloride of Copper, Muriate of Copper.—This salt, although much used on the continent in colour mixing, is almost unknown in this country. It is used in nearly all cases where English receipts give some other copper salt, as the sulphate and nitrate in combination with sal-ammoniac; although I believe sal-ammoniac is necessary even with the muriate of copper, but smaller quantities suffice. It is made by dissolving oxide of copper in muriatic acid, and concentrating until it crystallizes; liquid muriate of copper may be made from muriate of lime and sulphate of copper.

Nitrate of Copper.—This is mostly sold as a concentrated liquid; its principal use is in calico printing, where it is employed as an oxidising agent, as in the case of catechu browns, some steam colours containing logwood, chiefly browns and chocolates, and in several spirit colours. Nitrate of copper enters into the composition of a resist for china blue. The value of nitrate of copper is usually judged of from the strength indicated by the hydrometer: unless purposely falsified by other substances, this is a good enough test; if adulterated, only regular analysis can give its value. It is sometimes sent out too acid—not properly killed, as it is expressed. It is always acid, but there should not be any great excess present. A practical test of the comparative acidity of different samples consists in trying how much weak caustic must be put in a gill of nitrate of copper, before it begins to give a precipitate which does not dissolve on stirring: the more that is required, the more acid the liquor, and *vice versa*.

Acetate of Copper (Verdegris).—This salt is mostly made by the colour mixer, from a mixture of sulphate of copper and acetate of lead, using the clear liquid only. The commercial verdegris is not of regular quality, sometimes altogether insoluble, at other times more or less insoluble, and difficult to dissolve even with the assistance of acetic acid. Acetate of copper is not much used, and where it is employed it appears to be simply as an oxidising agent.

Ammoniuret of Copper.—When liquid ammonia is mixed with a solution of a salt of copper it gives at first a pale blue precipitate, but a little more ammonia causes this to dissolve, producing a rich purple colour. This solution, which may be called an ammoniuret of copper, has been employed to give a light shade of green, by simply padding in it, drying, and washing off. Ammoniuret of copper has the peculiar

property of dissolving cotton, reducing it first into a pulp, and then clearly dissolving it. This fact is recently discovered, and may possibly be applied to some useful purpose hereafter. Further particulars will be found in the section upon cotton.

Arsenite of Copper, or Scheele's Green.—Arsenious acid can, by proper management, be made to form a salt with oxide of copper, which has a pleasing green colour; it is extensively used for printing paper hangings, and as an oil colour. It can be produced upon cloth, but not with the same brilliancy as the dry powder. The method of dyeing this colour is to pad in a salt of copper, dry, and fix the copper by passing in a caustic bath, then pass into a beck containing the white arsenic dissolved, and keep in until the desired shade is obtained. Another method consists in padding in arseniate of soda, drying, then padding in nitrate of copper, washing off, and finishing with a short passage in weak acetic or nitric acid. This colour is very little worked now on calico or other fabrics.

Fatty Compounds of Copper.—Green colours have been used made from the fatty compound of copper, which is produced when blue vitriol is mixed with a hot and strong solution of soap. A soap of copper is produced which is not soluble in water, but which can be dissolved in turpentine, and so printed or padded; hung up in a hot stove the turpentine volatilises, and leaves the green copper compound upon the cloth. The colours thus produced are not remarkable for either brilliancy or fastness, and are now hardly ever made. Some samples in my possession have gone much yellower by age, though they have stood better than most metallic colours in the same conditions.

Copper is particularly injurious in madder dyeing in several states, and in very small quantities. One per cent of the hydrated oxide, or carbonate of copper, is sufficient to destroy the tinctorial power of madder altogether under ordinary circumstances. The soluble salts act quite as injuriously.

Nickel and Cobalt.—These two metals are too rare to be put to any practical uses in the arts; nor does it appear, from such experiments as have been made upon them, that they would be of any use in printing or dyeing. Both of them act as mordants, cobalt better than nickel, but the shades of colour which they give are not very desirable or valuable, and resemble those obtained from iron mordants.

CHAPTER XIV.

LEAD—NITRATE OF LEAD—SULPHATE OF LEAD—ACETATE OF LEAD—
CHROMATE OF LEAD—MERCURY—BI-CHLORIDE OF MERCURY—VER-
MILION — SILVER — GOLD — PLATINUM — GENERAL CHARACTER OF
METALS.

LEAD.

LEAD, as a metal, is still more indifferent to the action of chemical materials than copper; but, owing to its softness, it cannot be applied well except as a stationary fixed apparatus. It is well adapted for hot acids, holding tight, and lasting for years, where wood and stone have both yielded. It must be well supported on account of its softness, and, of course, without solder, the different joints being made by fusion, or burning, as it is technically termed. It does not withstand the action of aquafortis, but both vitriol and spirits of salts are without action upon it.

Lead has three combinations with oxygen, but only one of these forms salts, and this is the protoxide, composed of single atoms of lead and oxygen. When pure, it is white; with some little impurity, it exists in litharge, as a commercial article. Litharge has some few applications in dyeing and printing. In dyeing it is used for obtaining chrome oranges; in printing, it serves to purify caustic potash from sulphur, and to prepare basic acetate of lead.

Nitrate of Lead is made by dissolving litharge in hot aquafortis to saturation: it is not easily prepared, except on a large scale, in a state of purity. It forms white crystals, very soluble in water, in which they should dissolve without leaving any residue. They are very pure as sold by respectable drysalers, and not, as far as I am aware, subject to any regular adulteration. Nitrate of lead is employed as a mordant for

chrome yellow and orange; for the purpose of preparing a number of soluble nitrates from their sulphates, and in the mixing of the murexide purple, etc.

Sulphate of Lead is an insoluble salt, and precipitates whenever nitrate of lead or sugar of lead is mixed with any liquor containing sulphuric acid. It forms the bottoms from the making of red liquor when the acetates of lead are used, and from buff liquor in the same way. It is because the sulphate of lead is insoluble that sulphuric acid is used to pass pieces in, which are mordanted for chrome orange; the lead does not then wash off, and the pieces can be entered clean and free from gum, etc., into the chrome liquor. Sulphate of soda is sometimes used, but this is when there is some other colour on the cloth that the acidity of the vitriol would injure; the effect produced is the same, viz., the formation of a sulphate of lead. Although sulphate of lead is insoluble in water, it is a remarkable fact, that if the pulp be applied to calico, it enters into an intimate connection with the fibre, and after drying and hanging some time it cannot be removed by washing in water. Good solid chrome oranges can be raised in such a manner. It is used extensively as a resist in indigo dipping.

Chloride of Lead (muriate of lead).—This substance is nearly insoluble in cold water, but it dissolves in warm to some extent, and when the solution cools, deposits in fine shining crystals. It is not used in either dyeing or printing.

Acetate of Lead (sugar of lead).—This is a compound of acetic acid, oxide of lead, and water. There are two kinds in the market, known respectively as the white and brown sugar of lead. The white is the purest, and of more regular and constant composition than the brown. The heavy solid appearance of the brown sugar of lead induces the belief that it must be stronger than the fine powdery white kind, but this is not the case, as may be seen by the analyses; it is oftentimes much inferior, and unless there be some one on the works who can test its value, it should be repudiated altogether. If the brown is ever cheaper than the white, it is when used as a mordant for the sake of its lead, containing, as it usually does, more lead than an equal weight of white. But it should be remembered in the valuation of acetates, especially those of lead and lime, that it is the proportion of acetic acid, and not of base, they contain, for which they are useful, because, perhaps, seven-eighths of the whole quantity used is employed in the preparation of acetates, by way of double composition, from the various sulphates. Acetate of lead, as well as the nitrate, is used as mordant for chrome oranges.

Basic Acetates of Lead.—Solution of sugar of lead can dissolve powdered litharge by boiling, and thus forms several new salts, according to the quantity taken up, with one, two, three, up to as much as six times its regular quantity of lead oxide. Some of these basic acetates are used in dyeing, as mordants for the darkest kinds of orange, also in printing, but not much, on account of the difficulties in thickening them. Basic acetate of lead forms part of a receipt for a resist for China blues, but it acts more as sulphate than as acetate, on account of other ingredients in it.

Chromates of Lead.—There are two chromates of lead, the dichromate, or basic chromate, $2\text{PbO}, \text{CrO}_3$ which is of an orange red, and the mono-chromate, PbO, CrO_3 , which is yellow. The latter can be transformed into the former by heating it with an alkali, when it loses chromic acid, $2\text{PbO}, \text{CrO}_3 + \text{KO} = \text{KO}, \text{CrO}_3 + 2\text{PbO}, \text{CrO}_3$. It is worthy of note that that chromate of lead which is the most highly coloured contains the least amount of the colouring acid, and that the nature of the shades are exactly opposed to those of the chromates of potash. Both salts are in extensive use as pigments; the red chromate is a good deal used as a dye, while the yellow has not much use, but is frequently required, especially in printed indigo styles. In dyeing chrome orange the yellow chromate is generally produced first, by passing the mordanted cloth through bi-chromate, until it has well taken up the chromic acid; it is then changed into orange, by adding a proper amount of caustic soda to the liquor, and keeping in the pieces till they have taken the right shade. The orange could be as easily produced at once, and very frequently it is done so, by using yellow chrome salts, or converting the red chromate into the yellow, by adding a sufficient amount of caustic alkali. Or the yellow chromate of lead, instead of being changed into the orange in the same beck it is dyed in, is taken out, washed, and passed into boiling lime water, which changes it. In the case of employing caustic, care must be taken that no excess is used, for if there is more than necessary it robs the colour, and if the excess is considerable, it discharges the colour altogether. The action of the lime water and soda are similar, they deprive the yellow chromate of lead of part of the chromic acid, reducing it to a compound containing less chromic acid in proportion to the lead, and if the action is carried too far the alkali will remove the whole of the chromic acid, leaving upon the cloth only oxide of lead, which is white. It depends upon practical considerations whether it is better to use the one or the other method of obtaining the chrome orange, whether the orange should be obtained at once or by conversion of the yellow; in piece dyeing I

understand the former is the usual plan, while in calico printing the latter is the method usually followed.

Red Lead is a mixed oxide of lead. Though a bright looking colour it is not fit for printing on cloth ; probably if there was any means of forming or producing it on the fibre of the cloth it might be valuable, but at present the only method known of making is to roast the litharge at high temperatures ; it cannot be made in the wet way.

The Peroxide of Lead has a deep puce or chocolate colour, and can be fixed on cotton fibre. The process consists in mordanting in acetate, fixing in lime, and then passing in chloride of lime until the colour is obtained. The chloride of lime must be strong and warm. It is not a very permanent colour, and is very little made use of at present.

MERCURY : QUICKSILVER.

This metal, whose physical properties are well known, takes no part in either dyeing or printing. It is only seen in the shape of mercury gauges attached to steam boilers, in thermometers, and generally as the weight with which hydrometers are loaded. It is about thirteen times heavier than water, tarnishes when exposed to the action of heat and moisture, and forms a black substance, which is an oxide of the metal. Mercury has a tendency to amalgamate with most of the metals as soon as it is brought into contact with them. It penetrates, and deprives them of all their ordinary properties, making them powdery and soft. Therefore, this metal and all its salts must be kept out of contact with copper, tin, lead, or silver vessels ; iron is not acted upon by the metal, but is attacked by the soluble salts of mercury. The compounds which mercury forms with metals are called amalgams, and are so distinguished from the compounds of all the other metals amongst themselves, which are alloys.

The only compounds of mercury which have been much used, are the bi-chloride of mercury, or corrosive sublimate, and the acetate of mercury ; the iodide of mercury has been a little employed, but very little.

The Bi-chloride of Mercury is a heavy, dense, crystalline salt, requiring much water to dissolve it, of most disagreeable taste, and is a virulent poison. Its principal employment has been for the purplish red colour from murexide, the amaranth or Roman purple, and for use in this it is generally mixed with acetate of soda to convert it into acetate wholly or partially. Its chemical action in this case is to com-

bine with the murexide to form a salt of mercury, the composition of which is not well known, and which possesses the beautiful colour which distinguishes the new amaranth. As a rule, any colour of which mercury, or a salt of mercury, forms an essential constituent, will be a loose colour; for, although some compounds of mercury may be used in oil painting without fading, it must be considered that they are not exposed to the action of the air; the oil forms a varnish over them and protects them. But colours on calico and other fibres are exposed in a peculiar manner to the atmospheric influences and also to light, under the combined action of which the compounds of mercury are unstable.

Acetate of Mercury.—This salt can be produced in a pure state by dissolving the red oxide of mercury in acetic acid, it crystallises in pearly scales. For practical uses the acetate is made by adding acetate of soda to a solution of the bi-chloride.

Vermilion.—This is a compound of mercury and sulphur. Its brilliant colour is familiar, but it does not suit fibrous material; its great density also is an objection. Like red lead, this colour can be only obtained in the dry way, by means of heat; it cannot be precipitated or thrown down by mixing compounds of mercury and sulphur.

Iodide of Mercury is perhaps even a more brilliant colour than vermilion, but it is very unstable, and changes even when kept in a corked bottle; it has been applied to calico, but it could never be any good. The process of fixing consisted in adding solution of iodide of potassium to bi-chloride or nitrate of mercury, until the precipitate at first formed was re-dissolved; this was thickened and printed, and then passed in weak solution of the mercury salt to raise the colour.

Silver, Gold, and Platinum.—These metals are precluded from taking much share in the ornamenting of textile fabrics by their high price; in some parts of the world fashion demands their combination with woven materials, but up to this time there has been no good or useful chemical means of applying these metals. They are either fixed on by sewing, as tinsel or solid gold ornaments, or gold or silver thread is woven with the fibrous material, or else thin leaves of the metal are applied and made to adhere with ordinary gummy or resinous substances; further particulars concerning which may be found in the section on the generalities of the metals.

The following metals, viz, *Palladium, Rhodium, Osmium, Iridium, and Ruthenium*, are so scarce as to be of no possible application to manufactures, and do not call for any further notice in this place. For detailed information elementary chemical treatises must be consulted.

GENERAL CHARACTERS OF THE METALS.

Though the metals have a general resemblance with one another in appearance and properties, there are great differences in the degree in which the chief characteristics are possessed by them. The chemical character of a metal has been stated to consist in its capability of forming salts with acids. The physical characters of a metal are those by which a metal is recognised in ordinary circumstances, namely, lustre or brilliancy of a peculiar nature, fusibility and malleability, added to which, they are conspicuous by their superior power of conducting heat and electricity. It is not within the province of this work to enter into details upon the comparative powers of conduction of heat or electricity, nor the fusibility or expansibility of metals by heat; only general hints are offered. Metals vary in density, from potassium, which is lighter than water, to gold and platinum, which are about twenty times as heavy as water; tin, zinc, and iron are from seven to eight times as heavy as water; copper, silver, lead, and mercury are from nine to thirteen times the density of water. Metals are all good conductors of heat; gold, silver, platinum, and copper are the best conductors, and nearly equal. Iron and zinc have only about one-third of the conducting power of gold, and lead stands the lowest of the common metals. But the worst metallic conductor is much superior to the best conducting earthy or organic substance. Metals expand by heat in all directions, and contract to the original bulk upon cooling. In soft metals, as lead and tin, the expansion seems to be permanent in some cases, as in leaden steam pipes, which become longer, or leaden pans, which become wrinkled or distorted by heat. But there is no good reason for assuming that the metal is permanently expanded; it can only be said to retain the form it had when expanded, for want of elasticity to return to its original shape,—doubtless the metal resumes its original absolute bulk upon cooling. Copper expands more for the same heat than iron does—a fact which is sometimes taken advantage of to separate a copper roller from the iron mandrel, to which it has become so firmly attached as to resist the ordinary mechanical appliances for separating it. By plunging the roller and mandrel into boiling water until heated, the different expansibilities of the iron and copper operate, and usually permit the separation of the two metals. The ordinary metals stand in the following order for expansibility by heat, the first being the most expansible: tin, zinc, silver, brass, lead, iron, copper,

gold. The difference between the expansibilities of the metals is not considerable. The further effect of heat upon the metals is to melt them, and ultimately to cause them to enter into ebullition and be dissipated in vapour. The following is the order of the fusibility of metals, beginning with mercury, which is in a melted state at all ordinary temperatures, potassium, tin, bismuth, lead, zinc, silver, copper, cast iron; platinum and other metals can only be melted in small quantities by the oxyhydrogen blow pipe. Iron is the most tenacious of all the metals, a wire of it requiring a greater weight to break it than a wire of equal thickness made of any other metal. The unequal affinities of the metals for oxygen influence their applications in contact with chemical agents. In the following list the metals are ranged in order of their affinity for oxygen, those which have the more powerful affinities being first: potassium, sodium, manganese, zinc, iron, nickel, cobalt, lead, tin, bismuth, copper, silver, mercury, platinum. In most cases, the metal having a greater affinity for oxygen can reduce another from its solution; thus a slip of metallic zinc placed in a solution of nitrate of lead causes a precipitation of metallic lead, the zinc taking the oxygen and acid, and entering into solution; the same if iron be placed in a solution of copper, or if copper be placed in a solution of mercury. This observation is practically useful in calico printing and dyeing, where metallic solutions are employed. An iron or steel roller cannot be used to print a colour containing a salt of copper, nor can an iron doctor be used, nor an iron scope in contact with such a colour; solutions of copper should not be used in vessels with iron fastenings. In practice copper rollers are employed and doctors of brass. Again, copper will reduce mercury from its solutions; copper rollers would not, therefore, answer to print mercurial mordants, they would be covered with the reduced metal and the engraving destroyed. These observations only apply to cases where the metals are in solution: an insoluble salt of mercury has been printed by copper rollers. When two metals are in contact in a chemical medium, they are not acted upon in an equal manner, but that which is the more oxidisable is acted upon exclusively; thus, a copper pan which is tinned, is preserved by the tin from the action of acid solutions, though the tin may cover only a small portion of the copper. Metallic vessels which are soldered are acted upon by chemical agents at the point of junction most strongly, thus pans and rollers are injured; it is advisable, when possible, to have rivetted and not soldered vessels in contact with chemically active agents.

Metals as Applied to Cloth.—Metals in the state of thin leaves or fine powder have been applied to textile fabrics. There are several ways of fixing gold or silver leaf upon cloth, but only one that will stand washing or wetting; that consists in preparing the piece with fish glue and gum tragacanth, to make it full and stiff, and then printing on the design with an oil mordant, and when this has got into a proper state of thickness, by exposure to the air, applying the leaves of gold or silver, and pressing them with a leather cushion; the fabric is exposed some time longer to the air, and then it can be washed. The oil mordant consists of linseed oil, made drying, mixed with two ounces of fine ground litharge, and half an ounce of fused sugar of lead, to every pound of oil. Another process is to give the stuff several coats of clear fish glue until a moist hand laid upon it adheres slightly,—the stuff is hung up in a moist place until soft,—the leaves of metal placed upon it, and the design, in a block, struck on the leaf to make it adhere; the blocks are repeatedly rubbed with talc in powder, or French chalk, to keep the gold from sticking to them. To fix gold leaf on very open fabrics, as crapes or muslins, a skin is stretched upon a table and slightly rubbed with tallow; upon this the leaves of gold are placed in such positions as the design requires, and kept down by the tallow; the fabric to be printed is then laid upon this without disturbing the gold leaves, and the pattern printed on the back with a hot strong solution of fish glue, mixed with two ounces of gum galbanum to each pound of glue, or a good strong flour paste well boiled; the glue or paste pass through the fibre and cause the gold leaf on the other side to be attached to it.

Gold or silver colours, made from the metal in fine powder, the metallic lustre being obtained by burnishing, resist friction very well, but will not stand washing. They may be applied in a strong solution of clear Flanders glue, mixed with a soap made from wax, and, after printing, passed into alum water and then rinsed.

A metallic colour from tin has been applied. The tin was obtained in a fine state of division, by precipitating it from a solution of the chloride by metallic zinc, mixed up with the thickening, and printed on; the metallic reflection was obtained by burnishing, or passing the pieces through calenders.

Several patents have been taken out lately for gilding silk, etc., in the thread; the silk is tinted yellow, covered with a kind of size, and the gold leaf applied. Attempts have been made to deposit metals by electricity upon fibrous substances, but at present with no commercial result. The deposition of metals by pure chemical agency has also

been tried, but with no great success ; perhaps the best results in this line have been done under Calvert's and Schischkar's patents,—the metallic lustre in this case is apparently due to the formation of a sulphuret of the metal in the fibre of the cloth ; but I believe there have been practical difficulties in this which have materially prevented its extended application.

CHAPTER XV.

ORGANIC ACIDS—ACETIC ACID AND ACETATES—TARTARIC ACID—CITRIC
ACID—OXALIC ACID—FERROCYANIC ACID—PRUSSIAN BLUE.

Acetic Acid.—Many vegetable substances become sour by exposure to air and moisture, the sourness is in nearly all cases owing to the presence of acetic acid; vinegar owes its acidity to this acid. The chief source of acetic acid for manufacturing purposes is the fluid obtained by the distillation of wood in close retorts; it is at first a dark-coloured tarry fluid, but when purified is clear as water, of a strong penetrating odour and agreeable acid taste. The commercial acetic acid marks from 6° to 9° Tw., and is remarkable for not containing the same amount of acid at equal densities. It was pointed out long ago that the density of mixtures of the strongest acetic acid with water were, up to a certain point, greater than that of the acid itself, and I have noticed an irregularity of this nature in the commercial acid, so that one sample marking 6° Tw. was as good as another at 9° Tw., though the latter was free from impurity; in other cases the contrary was true, the denser acid being the best. Acetic acid should be tested for the mineral acids sulphuric and hydro-chloric, for solid matter in general by evaporation to dryness, and for copper and lead especially. Wood acid, or pyro-ligneous acid, is the crude product from which the purified acetic acid is obtained; it contains a number of undefined matters of a tarry nature, which communicate peculiar properties to it. It is used in the preparation of the crude acetates of lime and lead for the manufacture of mordants; and is employed to make the acetate of iron mordant. Free acetic acid is not much used in dyeing or printing; in those cases in colour mixing where it is employed it acts the part of a solvent, keeping the drugs and thickenings from coagulating or clotting, and permitting them to work smoothly in the machine. It is a non-corrosive acid, and

easily volatile when not combined with a base; with some bases it forms feeble combinations, from which it is expelled by heat; this is the case with alumina, the oxide of iron, and the oxide of tin. It is this property which makes the acetates valuable as mordants. Acetic acid forms compounds with all the metals; they are remarkable for being all soluble in water; they may be formed by the direct action of the acid upon the oxide, or by the indirect means of double decomposition between an acetate and a salt of the base required.

Analysis.—The value of commercial acetic acid can be estimated by ascertaining how much soda, or carbonate of soda, a given weight can neutralise. Inorganic acids, if present, would also neutralise the alkali. They must be either tested for separately, or the determination corroborated by evaporating the neutralised liquor to dryness, and calcining it at a red heat. All the acetate of soda is then converted into carbonate, the quantity of which may be dosed by the test acid: if it corresponds in quantity with the alkali first required to neutralise the acid there is no mineral acid present; if it falls short, the difference may be ascribed to some mineral acid whose soda salt is not decomposed by red heat. Good commercial acetic acid contains from eighteen to twenty-two per cent of anhydrous acetic acid, and only traces of sulphates and chlorides. I append some results of acetic acid testings:—

No. 1 R....100	grs. neutralise	62	grs. cryst. soda	= 23	per cent acid.
No. 2 R....100	"	67	"	= 24	"
No. 3 B....100	"	60	"	= 21	"
No. 4 K....100	"	58	"	= 20½	"

The samples one and two are above the average strength, numbers three and four are good average. Samples which indicate eighteen per cent are frequently met with.

A sample of pyroligneous acid, marking 8° Tw., only contained 3½ per cent of acetic acid.

In the analysis of the commercial acetates the chief attention must be given to the amount of acetic acid in combination, since that is the most valuable constituent. The acetates most in use are those of lime, iron, alumina, and lead. The acetate of lime is sold both as a solid and as a fluid. It can be analysed by precipitating all the lime by a slight excess of sulphate of soda, adding alcohol to the liquid to prevent solution of the sulphate of lime formed, washing with dilute alcohol, and determining the lime from the sulphate; the filtrate is evaporated to dryness, and calcined at a red heat to convert the acetate into carbonate of soda, the amount of which is ascertained by the alkalimeter, and the quantity of acetic acid calculated from it. I append analyses

of two qualities of acetate of lime liquor, supplied by a manufacturer in the neighbourhood of Manchester. The No. 1 is sold for the purpose of making the strongest red liquor; the No. 2 for preparing a weaker kind;—

	No. 1.	No. 2.
Acetic acid.....	9 5	4 1
Lime	5.2	2.13
Chloride of calcium.....	0.5	3.95
Chloride of sodium	3.22	3.40
Tarry matters	3.83	1.92
Water.....	77.75	84.50
	100.00	100.00

The chloride of sodium serves simply to increase the density; the chloride of calcium gives rise to some chloride of aluminum, which may be beneficial in those red liquors required to resist light covers of chocolate or purple.

Acetate of Alumina.—The analysis of this salt is not likely to give any correct idea of its value as a mordant; the only reliable test is to try it actually upon cloth in comparison with known qualities. The alumina may be determined by precipitation with ammonia; the acetic acid, by precipitating the alumina with carbonate of soda, exactly neutralising the filtrate with sulphuric acid, evaporating and calcining, as given under acetate of lime. I have found good strong red liquor to contain from 3.5 to 4.5 per cent of alumina, and some, which was not complained of, containing only 1.6 per cent. The amount of dry acetic acid should be equal to twice the weight of alumina in a red liquor.

Acetate of Iron.—Iron liquor may be analysed by passing chlorine through a weighed quantity of it, mixed with acid until quite peroxidised, then precipitating with carbonate of soda, and weighing the per-oxide of iron as such. To estimate the acetic acid, the clear filtrate, being exactly neutralised with sulphuric acid, is evaporated to dryness, and calcined to convert the acetate of soda into carbonate; the carbonate is dosed by the test acid, or by Fresenius' apparatus, and the acetic acid calculated from it: there should not be anything else but water and tarry matter; if there is, it must be determined by additional methods. Here is an analysis of a sample of iron liquor, which may serve to give an idea of what may be expected to be found in a good sample:—

Oxide of iron, calc. as FeO.....	6.30
Acetic acid	7.20
Sulphuric acid	0.80
Tarry matter	2.30
Water	83.40
	100.00

I have found other samples of iron liquor with only an imponderable trace of sulphates, and sometimes sulphate of lime present, indicating that the iron liquor, or some of it, had been made by double decomposition with acetate of lime.

Acetate of Lead.—The commercial acetate of lead contains three equivalents of water, $\text{Pb O, } \bar{\text{A}} + 3 \text{ HO}$; there are several basic acetates formed by putting the neutral acetate into contact with oxide of lead: they have an alkaline reaction to test paper. The commercial brown sugar of lead is an impure acetate, generally containing some basic acetate and insoluble salts. Here, as in the case of acetate of lime, the product is of uncertain composition, and must be analysed before its real value can be ascertained. Acetate of lead may be analysed by precipitating the lead as sulphuret by a current of hydro-sulphuric acid, and dosing the liberated acetic acid immediately by the alkaline test liquor; or, the lead may be precipitated as sulphate by sulphate of soda, the resulting acetate of soda converted into carbonate by burning, and the amount of acid thus indirectly determined from the alkaline carbonate produced. I append the analyses of two samples of acetate of lead, one a good sample of white acetate, the other good commercial brown acetate:

	WHITE ACETATE.	BROWN ACETATE.	THEORETICAL.
Acetic acid.....	27.6	21.8	26.84
Oxide of lead.....	58.4	59.9	58.95
Water	14.0	15.5	14.21
Carb. of lead and insoluble matter .....	.....	2.8	.....
	100.0	100.0	100.00

TARTARIC ACID.

Tartaric acid exists in the juice of the grape, which is the only practical source of it; it falls out of wine in the state of red tartar, impure cream of tartar, or bi-tartrate of potash. The pure acid is obtained by converting it into tartrate of lime, decomposing this with sulphuric acid so as to combine all the lime with the sulphuric acid and leave the tartaric acid free. It crystallises in large, clear crystals, which are very soluble in water, dissolving to a syrup; their taste is agreeably acid. As obtained from respectable houses, tartaric acid is in nearly a pure state, but it is said to be occasionally adulterated with the bi-sulphate of potash. This adulteration may be discovered by taking some of the pounded crystals and heating them to low redness. If the tartaric acid is reasonably pure, there will be nothing but a black coal

left, which would burn away at an increased heat, and which has no taste; if there be any bi-sulphate of potash present it will show as a white ash, which will have the well known acid taste of the bi-sulphate, and which will not burn away at any heat, or with any length of time. A sample of acid can be judged of by simple inspection if it is in crystals, but if ground, only testing can tell what its quality is. Tartaric acid is at once a strong and a mild acid; it has powerful affinities, but it is not corrosive, and does not injure the finest fabric to which it is applied. It is largely used both in dyeing and printing, in dyeing more generally as the bi-tartrate of potash. Besides its acid properties, tartaric acid possesses properties of a singular nature, in masking or hiding the characters of metals with which it is mixed: for example, if caustic potash be mixed with the sulphate of copper dissolved in water, it will precipitate or throw out all the copper, but if tartaric acid be previously mixed with the sulphate of copper, potash will not produce any precipitate; many other metals behave with it in just the same manner. Tartaric acid is used principally in steam colours for blue and green; its effect in steam blue is to take potash from the yellow prussiate and leave its acid, the ferrocyanic, at liberty to react upon the other components and upon itself to produce the blue; the tartaric acid forms bi-tartrate of potash, which continues the action, being itself an acid salt. It is also much employed as a discharge on dipped blues and Turkey red.

Tartaric acid combines with potash to form two compounds, known respectively as the tartrate and bi-tartrate, the first containing only half as much acid with reference to the potash as the other. The simple tartrate is very little known in practice, it is a neutral and very soluble salt. The bi-tartrate is the form in which the wine deposits the tartar mixed with other substances, and with the colouring matter of the wine; in this state it is called either simply tartar, red tartar, or argols. It can be used in dyeing in this state, but it is usually purified by dissolving in water, separating the impurities and re-crystallising, in which state it is called cream of tartar; it is in crystals of small size, hard and gritty to the teeth, and having a slightly acid taste. A further purification brings it into a white crystalline powder, and it is thus used in the finer kinds of printing and dyeing. It is very little soluble in water, and cannot be made to mark more than two degrees Twaddle at natural temperatures. It dissolves much more if mixed with potash or soda, but then it loses some of its principal properties. In calico printing its uses are few, and mostly such as could be replaced by tartaric acid, but the cream of tartar is thought to act more mildly upon some

delicate shades, as cochineal pink. In dyeing it is used for mordanting woollen goods in conjunction with alum and the salts of tin. It is not quite clear in what the chemical action of the cream of tartar consists in this case; in the first place it seems to correct bad waters; if they are very hard and contain much lime it appears to prevent it falling on the cloth to its injury; if the water contains iron, it forms combinations with it which keep it from injuring the stuffs to be mordanted, probably by holding the iron in some condition in which its active properties are for the time being suspended; it takes some part in the saturation of the strong acid of the alum or muriate of tin, permitting their bases to pass more easily into the fibre of the wool. As an addition to the actual dyeing, tartar acts no doubt in two ways; firstly, as a corrective with regard to lime and iron in the water, and, secondly, as a mild, acidifying agent; for wool does not take colours well unless the bath is slightly acid, and tartaric acid and cream of tartar are the best acids which can be used for the purpose.

The present high price of tartaric acid, and the probability of its future scarcity, should turn attention to the cases in which it can be replaced by the cheaper mineral acids. There are certainly many cases in which tartaric acid and bi-tartrate of potash are employed in dyeing where any other acid would answer the purpose equally as well if used with care. Many of the colours which were formerly supposed to require tartaric acid are now produced by the substitution of sulphuric acid; but in the finer styles of work, where economy in drugs is not so much considered, tartaric acid is preferably employed, because it can be used more freely, and without danger of an excess producing injury to either the colours or fabric.

The cost of tartaric acid and the irregularity of its supply have led many persons to seek for a substitute; several have been patented, and others privately offered in the market. Arsenic acid has been proposed, but has not answered, and in low class printing the bi-sulphate of potash is frequently used instead of tartaric acid.

The commercial substitutes are of very various composition, some containing a considerable proportion of crude tartaric acid, mixed with sulphate of potash and common salt; others contain no trace of tartaric acid; and some, according to the specifications of the patentees, cannot be anything but mixtures of two or more of the mineral acids, with sometimes a salt of tin, and sometimes a salt of alumina.

Such substitutes are simply commercial, they have none of the peculiar chemical powers of tartaric acid.

Tartaric acid may be tested by the amount of carbonate of soda it will

neutralise, and the freedom from mineral acids, ascertained by the same method as in the case of acetic acid. I have always found crystallised tartaric acid to be within two or three per cent of theoretical purity.

CITRIC ACID.

This acid is obtained from the juice of lemons, limes, and similar fruit; when pure it is in colourless crystals, of a strong, pleasant, acid taste, dissolving easily in hot or cold water. The pure acid is not much used either in dyeing or printing on account of its high price; but, in some places it is employed as a resist on madder work, and for throwing down the colouring matter of safflower after it has been dissolved by alkali; but for either of these purposes ordinary lime juice, of good quality, will answer nearly, if not quite, as well. Citric acid is occasionally adulterated by admixture with tartaric acid, which, besides being a fraud, is liable to cause much injury to the printer. It is possible to discover five per cent of tartaric acid, and any greater quantity, in citric acid, by means of caustic potash, in the following manner:—Dissolve a couple of ounces of the acid to be tested in as little water as possible—from three to four ounces at the most—then take one half the solution in a glass tumbler, and add strong caustic potash (soda will not do) drop by drop until the acid is neutralised, then mix with it the other half of the dissolved acid, and stir well up together: if a heavy white crystalline powder falls to the bottom of the glass, it indicates tartaric acid; if the quantity of tartaric acid is small, it will not appear directly, and the glass should be left for about six hours in a cool place, when, if the liquor is quite clear, or only a little gelatinous substance in it, the citric acid may be considered as being free from tartaric.

Lime Juice or Lemon Juice.—The acidity of this juice is owing to citric acid, and its value depends upon the quantity of this acid which is present in it. Lime juice is very variable as to quality, depending upon the method of extraction, the quality of the fruit, and the honesty of the shipper. The best kind in the English market, for the use of printers, is a dark treacly-looking fluid, marking from 48° to 54° Tw., and containing from thirty to thirty-six per cent of pure citric acid. There are many inferior qualities, which, though standing nearly as high on the hydrometer, contain not more than two-thirds or one-half of that quantity of real acid. The sellers in this country charge the acid so much per gallon per degree. What these degrees mean, or how they are obtained, I am not informed; they do not correspond with any hydro-

meter that I am acquainted with, nor with the amount of real acid in the lime juice. At certain times all lime juice is bad, containing a great deal of sediment, and some peculiar substance, which prevents it giving good whites as a resist for madders and garancine work. This is understood to be owing to a bad harvest of limes: the quantity of fruit being much less than usual, the manufacturers abroad appear to press it more completely to make up the quantity, besides using damaged fruit, and substances whose only resemblance to limes or lemons consists in their giving some kind of juice; but the citric acid, the real active element of lime juice, is not there in the proper quantity, or is injured by a mass of other matters. It may be generally observed that as lime juice becomes dearer its quality deteriorates, as it becomes cheaper it gets clearer, with less sediment in the cask, and sharper and more agreeable to the taste. The strength of lime juice cannot be well ascertained by Twaddle; the real test is to ascertain how much alkali it will neutralise, and that no cheap acid has been added to make it apparently strong. I have found lime juice adulterated with potashes, which raises the density without, for a certain quantity, materially injuring its resisting power; for citrate of potash itself is known to resist tolerably well, and especially when mixed with free citric acid. This adulteration can be detected by mixing very strong solution of tartaric acid with the suspected lime juice; if potash be present there will be formed, in a short time, a crystalline deposit of bi-tartrate of potash at the bottom and on the sides of the vessel. It must be observed that some potash is naturally present in lime juice, and care must be made to distinguish between what may be allowed and what is evidently a falsification. Citric acid is made from lime juice by adding ground chalk to the acid mixed in water, washing the citrate of lime from the impurities which are dissolved in the water, and afterwards decomposing it with sulphuric acid; if the citric acid is not white enough, animal black is used to decolorise it. It is possible for the calico printer thus to purify his lime juice, and to make it into citric acid if he thinks proper. Citric acid, whether in pure crystals or in lime juice, is the best resistant for iron and alumina mordants; its power does not rest simply in its acidity, although that is very great, being able to neutralise or dissolve nearly as much of an oxide as an equal weight of oil of vitriol, but partly in a power like that of tartaric acid, of masking the usual properties of metals and putting them beyond the action of the agents usually influencing them; that it is not simply the acid, is evident from the fact that when the acid is quite neutralised, with either potash or soda, the citrate of potash or soda is, for the quantity of citric acid present in any

given bulk, nearly as good as before for resisting, though it cannot act as a discharge. When an iron mordant is printed over a citric acid resist, citrate of iron is formed, which, unlike the majority of the salts of iron, does not oxidise on the cloth, even when exposed for a very long time to the air, and which can be removed from it by simply washing in water, the usual fixing agents having no action upon the salt. When citrate of potash is employed its first action is mechanical, to receive the superimposed mordant, afterwards effecting a decomposition by which citrate of iron is formed, and the oxide so kept from fixing itself upon the cloth. That citric acid has the power of changing the bearings of metals to other bodies, is capable of being easily proved. If caustic potash be added to a weak solution of copperas, it precipitates all the iron as oxide; but if a sufficient quantity of citric acid be mixed with copperas, and then potash added in any quantity, there will be no precipitate formed, owing to some agency of the citric acid; the same or a similar agency keeping the iron or alumina of the mordant from precipitating upon the cloth whenever it meets the citric acid.

The combinations which citric acid makes with the alkalies and metals are not employed in dyeing or printing, except the citrate of soda mentioned above, which is used to resist catechu brown, and in one or two other cases.

Analysis.—Citric acid, or lime juice, may be tested in just the same manner as acetic acid, by a graduated alkaline solution. I have found citric acid to contain as much as 10 per cent of tartaric; this was in a sample of brown acid sent as of the first crystallisation; without doubt it was purposely adulterated. I have never found the finished white crystals adulterated.

Lime juice is only valuable on account of the citric acid which it contains, and which varies considerably. A good quality of lime juice, marking from 46° to 50° Tw., will neutralise from 70 to 76 grains of pure crystallised carbonate of soda. For commercial purposes, each grain of carbonate neutralised may represent a half grain of crystallised citric acid, and the value of the lime juice be calculated in proportion. Upon evaporation and calcination at a red heat, the citrate of soda will be converted into carbonate, and, being tested by the alkalimeter, should indicate the same amount of alkali as was at first added: sometimes it will be found to indicate more, which arises from potash present in the lime juice: to correct this, a quantity of lime juice should be evaporated and incinerated separately. I have had occasion to test samples of lime juice not containing more than 18 per cent of citric acid, although marking full strength on the hydrometer: they were overloaded with vegetable extractive matter.

OXALIC ACID.

Oxalic acid exists naturally in the juice of some plants in a state of combination with potash, and for many years there was no other method known by which it could be obtained than from the plant. At length it was found that when nitric acid acted upon sugar and some other vegetable matters of the same or similar composition, it produced oxalic acid, and until very lately all oxalic acid was thus produced. Messrs. Roberts, Dale, and another have recently patented quite a new method of making it from sawdust, and instead of an acid use alkalies. Oxalic acid is sold in a crystalline state, the crystals are small and soft; it is very acid to the taste, and does not dissolve to any great extent in cold water. It is a powerful and energetic acid, and, as proved by Mr. F. C. Calvert, has a destructive action upon fibrous substances when heated to high temperatures with them, but at the ordinary temperatures of drying and steaming the pure acid has no injurious action, and may be safely used without fear. It is not very much employed in either printing or dyeing: it serves for a discharge in some cases; used to a small extent in several steam colours, to form oxalate of alumina; occasionally employed as a mordant, and to form an acid oxalate of soda; used as a half resist on steam work.

Oxalate of potash is usually found in printworks, where it enters into the composition of some colours, and may be viewed as a milder form of oxalic acid.

The degree of purity of oxalic acid can be practically ascertained by heating a small quantity in a hollow metal cup: if pure it will pass away in vapour, and leave no residue of any kind; if it only leaves a film, it is not to be accounted bad; but if it leaves a considerable quantity, which does not disappear at red heat, it is an indication of some impurity or adulteration.

Formic Acid.—This acid has some relation to oxalic acid in composition, but to acetic acid in its properties. I made a quantity, and tried it for several purposes, but I found that it was in everything very like acetic acid. With proper management formates of alumina and iron can be made, which are at least as good mordants, and fix as easily as the acetates; but, as the formic acid would be more expensive, and did not present any special advantages over the acetates, the subject was not followed out.

Ferrocyanic Acid.—This is the supposed acid of the yellow prussiate of potash, but chemists are not quite agreed as to the exact way in which

the composition of these complex salts, the prussiates, should be represented. This acid is not a commercial product, nor is it made in dyeing or bleaching for any purpose; though sometimes formed in various processes when acids and prussiates are brought into contact. This acid is quite distinct from prussic acid, though belonging to the same group of bodies; its salts are not poisonous, while the salts of prussic acid, as well as prussic acid itself, are violent and instant poisons. The chemical name for yellow prussiate is ferrocyanide of potassium, while the name of the salt produced from prussic acid and potash is cyanide of potassium.

Yellow Prussiate (ferrocyanide of potassium).—This useful salt is made by fusing animal substances, as guano, hoofs of cattle, etc., with potash and iron. Its chemical components are carbon, nitrogen, oxygen, potassium, and iron. The iron which it contains is in a peculiar state of combination, and does not show like iron in its usual state in salts; but the action of acids upon it is to decompose the salt and make this iron apparent, turning it then into Prussian blue, by combining it with another part of the same salt. Yellow prussiate as generally sold is in a nearly pure state. If a simple examination of it leaves its quality doubtful, there is no other way of trying its goodness than either a regular chemical analysis or making colours from it in comparison with prussiate of a known quality. It is used in dyeing for making various shades of blue, by passing the goods alternately in some iron bath, and then into the prussiate made slightly acid. In printing no iron can be used, and the blue is made from the prussiate's own iron. It is not used except as a producer of blue. Although many of the metals give particular coloured precipitates with it, none of them have been found of any practical value except the Prussian blue, which is a prussiate of iron. It is used to make the Prussian and Chinese blue, used in finishing and spirit colours; from it red prussiate is made, and it serves to prepare prussiate of tin, or tin pulp, for steam blues.

Red Prussiate of Potash.—The salt is made from the yellow prussiate by passing chlorine gas over or through it. Its properties are somewhat different from those of yellow prussiate, though of the same general class; it is easily distinguished by not giving any blue colour with a per-salt of iron, which the yellow prussiate does. Mr. Mercer found that a mixture of red prussiate and caustic potash possessed peculiar powers of oxidation, the most interesting of which to the calico printer is its discharging effect upon indigo blue. If a piece of dip blue be soaked in solution of red prussiate and dried, and then dipped in moderately strong caustic, it will be entirely bleached; the same thing happens if it be dipped at once into a mixture of red prus-

siate and alkali. This interesting reaction has not been taken much advantage of on account of some practical difficulties and the comparative expensiveness of the process. The discharging of the indigo blue is owing to its oxidation, and in so far resembles the regular process in which bi-chromate of potash is used. The difficulty in applying this discharge to calico lay in its acting too quickly, and its being difficult to thicken the mixture of caustic and red prussiate; all the ordinary thickenings were more or less oxidised and destroyed; at the same time the mixture lost its discharging power. It has been proposed to use calcined magnesia instead of potash to mix with the red prussiate. No action takes place until the cloth is steamed or otherwise heated, then the blue is discharged. I have made trial of this plan, but I do not think that it is likely to be employed, for it is even more expensive than using potash and quite as uncertain.

Red prussiate is used by dyers for obtaining peculiar shades of blue. If cotton cloth be passed in the usual way through nitrate of iron and rinsed, it will take no blue when put into red prussiate, but if it is passed into muriate of tin liquor it strikes a blue directly, which has a good shade. The shades of blue produced by the yellow and red prussiates are not precisely the same, one being preferred in one place and another in another, according to the peculiar demands of trade; by mixing the two it would be possible to modify the reflection and hue of the colour produced. Red prussiate is not much used in printing; it is found in some receipts for dark steam blues, and for a few other colours, as myrtles and chocolates.

A liquid is sold as a substitute for red prussiate under the names of chloro-prussiate liquor, red prussiate liquor, &c. It is the mother liquor from which red prussiate crystals have been obtained, and contains all the chloride of potassium produced in making the yellow prussiate into red, besides any impurities which may be formed in the process; it is not a safe substitute, nor is it always a cheap one compared with the pure crystals.

The chemical name for red prussiate is ferridcyanide of potassium. The best criterion of its purity is the size, colour, and clearness of the crystals; the iron test may be applied to see if it contains any yellow prussiate unchanged. It should lose no weight upon drying, and should dissolve completely in water without residue.

Prussian Blue.—This is a prussiate of iron, and it may be either a ferrocyanide or a ferridcyanide of iron, as it is made from yellow or red prussiate. It is insoluble in water, destroyed by caustic, which forms one of the alkaline prussiates from it, and leaves the red oxide of

iron; some varieties dissolve in oxalic acid, and others do not. Muriate of tin and oxymuriate bring it into a kind of solution, and in this state it is applied as a spirit colour. Dissolved in oxalic acid it forms a good blue liquor for finishing, correcting the yellowish tone of garancine whites, when these are not well cleared. Not much is known of the actual composition of the various Prussian blues.

Prussiate of Tin, or tin pulp, is used only as an ingredient in the making of steam blues on calico and delaines. It is made by mixing proper quantities of muriate of tin and yellow prussiate; the more water employed in mixing them the finer will the pulp be and the better to work. If practicable, the prussiate should be dissolved separately in one-half the water, and the muriate mixed with the other half, and both then poured together into the vessel in which the pulp is to settle. Another pulp is made from the bi-chloride or per-chloride of tin instead of the muriate; but I am not sure that there is any advantage in using it instead of the preceding: some very fine blues have been produced by using a mixture of the two pulps.

In mixing dark steam blues it frequently happens that large quantities of prussic acid are developed from the hot colours, and sometimes men working over the pans or mugs are stupefied or sickened by the smell. There should always be good ventilation, but in default of that some ammonia liquor sprinkled about will relieve the place a good deal; or inspiring its vapour, not too strong, is perhaps the best restorative for men affected by these exhalations, combined in several cases with dashing cold water on the face.

CHAPTER XVI.

NEUTRAL ORGANIC BODIES—SUGAR—AMYLACEOUS SUBSTANCES—STARCH—
FLOUR—GUMS—ALBUMEN.

Sugar.—Sugar is only sparingly employed in printing; as mentioned under chromium, it is used to reduce the chromic acid in forming some chrome shades. But, though it is not directly employed, it is often present in cases where it is not suspected, and exercising such chemical actions as it possesses. A kind of sugar, known as grape sugar, from having the same composition as the natural sugar existing in grapes, is easily formed from vegetable substances by the action of acids; and it not unfrequently happens that saccharine matters exist in colours, produced from the prolonged action of acid and heat upon the thickening. A species of sugar is found in madder roots, and also in some varieties of artificial gums, particularly the light coloured gums, made by the action of acids. The presence of sugar is injurious to the fixing of mordants; saccharine matter acts, like many soluble organic substances, as if it suspended the chemical properties of the salts with which it is in contact, especially metallic salts. I thickened some iron liquor with molasses, and different mixtures of gum and molasses,—the colours printed well, but when hung up to age became sticky and damp, especially the one which had no other thickening but the molasses; when dunged and dyed, it was found that the molasses in the pure state had entirely prevented the fixation of the iron. The outline of the pattern could be just discerned in certain lights; the others were bad in proportion as they contained more or less molasses. The influence of saccharine matter in dyeing is not so marked; it does not produce any visible effect unless in excessive quantity.

The kind of sugar which is made by boiling weak sulphuric acid

with potato starch, and which is known as glucose, or grape sugar, possesses powerful reducing properties; it has been long known that it would dissolve indigo in contact with alkali, as orpiment or proto-salts of tin do, making a kind of pencil blue. A patent has been recently taken for a new method of fixing indigo by means of glucose, or grape sugar; the indigo, finely powdered, being mixed with the alkali, and the glucose, printed and steamed. An application of the same glucose is mentioned under the suboxide of copper. It seems probable that this substance, at present almost unknown in printworks, may turn out useful in some cases, when practical men are more familiar with its properties, and probably serve some useful purpose in the direction of indigo colours.

Amylaceous Substances.—*Starch, Farina, &c.*—Starch is a widely diffused vegetable product; it exists in a vast number of plants, fruits, and trees, and seems to be one of the fundamental bodies of organic life. Its composition is very similar to that of sugar, being a compound of carbon, with hydrogen and oxygen, in the proportions requisite to form water. It is extensively used in printing and finishing, but does not, in either case, exercise any actions of a purely chemical nature; as a thickening it is only a vehicle for conveying the colour or the mordant to the fibre; as a finish it is only to give stiffness or fulness to the cloth. But its actions in many cases involve the play of chemical affinities, and should be minutely known. Pure wheaten starch, when closely examined under the microscope, is found to be composed of very small globules. In commerce it is found in a peculiar state of aggregation, incorrectly said to be crystallised; the quality of the starch is often judged and determined by the appearance of these columnar masses, called crystals. No other starch but that from wheat takes the same form in drying. It is not prudent, however, to depend too much upon this as a test; for I believe this character can be communicated to other starches, and that it is not an essential character of wheaten starch, but rather an accidental one, due to a partial decomposition and breaking up of some of the globules, which communicate a gummy nature and adhesive character to the remainder. Starch does not dissolve at all in pure water when cold; it mixes up, but then settles down, leaving the liquid clear; it dissolves in hot water, swelling out to a great extent. It begins to dissolve, or the particles to burst, at about 150° Fahr., but colour cannot be well thickened at this heat, it must be boiled to get a good result. Starch boiled with acids or acid liquors thickens at first, but afterwards becomes thin, owing to the destruction of the starch and its conversion into sugar; colours should not, therefore, as a general rule,

be boiled until they begin to grow thin again,—although in special cases this is prescribed, and is an advantage, but it is usually unnecessary, and likely to injure the colour.

A good wheaten starch is white and clear, has a sweet taste on the tongue, or at least an absence of bad taste, and, before dissolving in the mouth, shows a stickiness or adhesiveness on the tongue; when mixed with water it should give a white milky fluid, without any particles of dirt floating on the top, and should settle down quickly, forming a solid hard mass at the bottom of the fluid. As a trial for its thickening powers a quantity may be boiled with water in the usual manner; two proportions should be taken, one thicker than is generally required, and another thinner—for instance, one trial at one pound to the gallon, and another at two pounds per gallon, and both boiled with the usual precautions. The manner in which it behaves on boiling, as well as its appearance when boiled, should be observed. A good starch will thicken gradually and evenly throughout, not in lumps; it will keep smooth all the time with only a moderate amount of stirring, and when boiled will be of a clear, transparent, gelatinous appearance—not milky and opaque, nor breaking off short when lifted with a stick. At two pounds per gallon it ought to be pretty stiff while hot, to pour out slowly, and for the most part adhere to the sides of a gallon mug, when this is inverted, for a short time; at one pound per gallon it should flow smooth and oily, without appearance of water or breaks in it. When cold, the thick trial should be very stiff, and feel tough and solid in the hand; the skin should be of a tough leathery nature, and no water should be floating about—it will not be so clear as when hot, but still should be partially transparent: the thinner trial should be also of increased consistence, and not show any water; it should be smooth, and not containing lumps. There are besides these characters a great number of others, too minute to record, which combine in forming the opinion as to the quality of a sample of starch. It is a practical question, and nothing but a number of trials, upon all kinds of starches, will enable anyone to form a correct opinion upon this matter.

Starch is sometimes adulterated with mineral substances, as gypsum, sulphate of baryta, or mineral white, China clay, etc. The existence of these substances make a starch boil rough and opaque; they can be discovered by burning some of the starch in a proper manner,—if much earthy matter be left as a residue, it will be a sign of adulteration. It is sometimes understood that starch for finishing contains mineral matters, and a proportionable reduction in price is made, but oftener there is only one party cognisant of it; at any rate, a starch containing

added mineral matter ought not to be used in mixing colours, however good it may be as a finishing starch. Inferior qualities of starch, under the names of seconds, slimes, and hair powder starch, are extensively used in the trade, and may be economically and safely employed in numerous cases; for it is not necessary, in making colours, that a starch as pure as is required for clear-starching linen should be used: what is required is a good sound article, free from adulteration, not injured by acids or fermentation, and, if otherwise good, it does not matter whether it be in powder or in crystal, perfectly white or a little greyish. Starch is sometimes injured by some of the gluten of the flour being left in it. Such a starch does not keep well, soon goes watery, or putrefies, emitting bad smells. By scattering a little of this kind of starch upon a red hot iron plate the gluten makes itself apparent, by giving off a disagreeable animal smell, like burning woollen, or leather, or the hoofs of horses. This kind of starch has never a good colour, and, if in crystals, has a flinty hardness. Good starch does not contain more than ten or fifteen per cent of water; the latter is the largest quantity it should lose in drying, at moderate temperatures.

There are other kinds of starchy substances in occasional use for printing and finishing which deserve a notice, as potato starch or farina, rice starch and sago flour,—which is not a flour at all, but nearly pure starch.

Farina, from the brittle short paste it gives, with water, cannot be used as a thickening. It does not work well; it may be sometimes worked with other thickenings, but it is very little good. It is used in finishing in conjunction with other substances—its tendency is to give a hard finish. Calcined farina is made from it.

Sago Flour.—When this is purified from chips, leaves, dirt, and colouring matter, it can be advantageously used in finishing, as a partial substitute for the more expensive wheaten starch. It works up softer as a paste than farina, and I think could be used in colour mixing with safety and economy. It serves to make gum from.

Rice Flour Starch.—This has been employed in finishing and thickening, but not to any considerable extent I believe. It is more used in finishing than as a thickener. It is employed in the manufacture of artificial gums.

Flour.—Wheaten flour forms a very useful thickening in colour mixing, and on account of its cheapness is extensively used. Flour, as a chemical body, may be looked upon as a mixture of starch and a peculiar substance called gluten. It is in proportion to the amount of gluten contained in flour that it is valuable as an article of human food, but

for the colour mixer, other things being equal, it is the amount of starch that renders it more or less valuable. The gluten has no sensible thickening power of itself, but it certainly influences the starch in its manner of thickening colours. A person who is acquainted with the properties of flour, and also the properties of the starch and gluten derived from it, viewing them as used for thickening colours, may entertain doubts as to the existence of the starch and gluten as such in the flour. A given quantity of flour thickens much better than the amount of starch which can be obtained from it : thus, the thickening power of a flour, though in relation to the starch it contains, is as a rule greater than that would account for, and leads to the belief of the existence in the flour of some form of starch decomposable by weak chemical or mechanical agency, and from which the substance called gluten is formed. The very best kinds of flour are weaker for thickening than common kinds, requiring from half a pound to three quarters more to the gallon of water, but they have an advantage in the fineness and smoothness of the paste they give, and their consequent better working in the machine. A part of this is doubtless owing to the greater quantity of gluten they contain, which I consider is the substance, giving toughness and tenacity to paste colours ; something is owing to the absence of inactive matters of a cellulose insoluble nature present in inferior flour, and a good deal to the fine dressing which such first quality of flour receives. As a chemical matter, flour has no particular affinities or actions ; it is not affected so easily as starch by acids or other chemical bodies.

Flour is occasionally troublesome, through grit or sand being present, which it is impossible wholly to remove by straining. The coarser or worst parts of the grit may be thrown out by a little careful management before boiling, as it settles down rather quickly in the thin mixture of flour and water, or flour and red liquor. If a quantity be mixed in a tub, of a churn shape, wider at bottom than top, and the mixture be kept quietly revolving, just so much as to prevent the mass of flour sinking, the greatest part of the grit may be brought towards the bottom. The top part can then be drawn off by a spigot, placed about six inches above the bottom of the vessel. This plan requires a little address to make it answer, but it will sometimes remove all real causes of complaint. The portion at the bottom can be used up for designs or patterns that are open, and do not show the action of the grit so much. The complaints of grit being in the colour are confined to particular times and seasons, and I believe are more to be attributed to the particular style of work in the machine room, than to any difference in the quantity of grit in flour. I have regularly

ascertained the exact quantity of grit in flour and other thickenings, and at times when it has been the worst no complaints have arisen. At other times, when the amount present was not above the average, the complaints have been loud and incessant, disappearing at the end of a few days in as unaccountable a manner as they arose. Flour, starch, and gum always contain some grit, but the amount varies very much; if it comes to one per cent it is very bad. At five grains to a thousand it is still bad; but at two grains to a thousand I think it cannot be avoided by any care on the part of the miller. It is impossible to remove grit by straining. Sand and bran will come out in a fine strainer, or a fine printing fent, but not that which I call grit. It can be separated by chemical means, and shown separately; it is a fine powder, that looks and feels in the fingers like dust; but under the microscope and between the teeth, which are the best practical detectors of grit, it can be proved to be hard crystalline sand, scratching copper and steel, and taking the polish or the face off a roller like fine emery or glass paper. In the section treating of gums some more particulars may be found upon the matter. Flour sometimes gives much trouble through some stringy, fibrous, tenacious substance, which forms in the paste. Only damaged flours do this, and I attribute it to some altered state of the gluten. The matter I speak of collects under the doctor, and drags out the colour from the engraving. It is found, on taking off the doctor, as round flattened globules (the shape, I believe, being given by the revolution of the roller), about the size of a pellet or larger. They have an india-rubber elasticity and feel: a straining takes them out; very often they form again on working. This substance appears under certain conditions in the cooled colours before going to the machine. If a hot paste colour be strained it seems free from them, and in twelve hours a pint or so may be obtained from three or four gallons by a fresh straining. The shape and marks of this substance lead to the belief that it existed in the hot colour in some soft plastic state, and was forced through the strainer by considerable pressure; never forming an integral part of the mass of the paste, but upon cooling getting hard and tough, and able to resist pressure on the strainer, while the real paste goes through. There seems to be no cure for this but changing the supply of flour; the mischief is done in the flour and cannot be undone.

The best and only test of any practical value for flour is to make a trial of it in thickening, observing how much it takes to give a good consistent paste. About 24 ounces to a gallon of water should make colours thick enough for all usual purposes; it should remain firm when cold, and not show any tendency to break or become watery.

GUMS.

The name of gum is given to any substance exuding from trees or vegetables, and drying up in the semi-transparent, globular shaped masses we are accustomed to see in gum arabic. But another distinction must be made: some of these substances are of a resinous nature, and not acted upon by water. Gums may, therefore, be divided into gums proper and gum resins; the first being those soluble in water, the second including such substances as copal, gum benzoin, etc., which are called gums by the varnish makers, but which possess none of the properties which characterise gum arabic, the type and model of gums. A good gum is known by dissolving easily in water, to which it communicates a thickness or viscosity of a different nature to that given by flour or starch; being fluid, easily poured from vessel to vessel, flowing with a long unbroken stream when poured from a height, and not going thicker by keeping, provided evaporation does not take place. The chemical composition of natural gums is nearly the same as that of starch, and their chemical relations to other bodies much of the same nature, that is to say very feeble and insignificant. It is this indifference which makes gum so valuable an agent in thickening colours; it does not interfere in the reactions of the various drugs upon one another, and interposes no obstruction to their combinations with the tissue, except such as are of a physical nature and inseparable from matter in its most inert form. There are only three or four compounds which cannot be thickened with gum in all the range of ordinary colour mixing, and they are not often employed. There is the sulphate of chromium, which frequently coagulates the gum water but not always; I consider it is a deficiency of acid which causes it to coagulate; the basic acetate of lead forms a combination with gum of a curdy nature, quite unfit for printing, and the solution of protoxide of tin in soda the same. These, and one or two other mixtures must be thickened when required, either with sugar or some of the artificial gum substitutes to be mentioned afterwards. The principal natural gums in use among printers are as follows:—

Gum Arabic.—This is the most expensive and finest kind of gum, seldom used in print works, but it may be taken as the sample of what a gum ought to be—in colour, solubility, and in keeping its fluid condition without any tendency to go sour. What is frequently sold as gum arabic is only picked gum senegal. It is employed principally in the fine arts, and for finishing crapes, silks, and similar goods.

Gum Senegal.—This is next in quality to gum arabic, and for all

ordinary purposes, and certainly for calico printing purposes, it answers as well. It is a coarser looking gum, and when unpicked consists of masses of various sizes and colours. A good portion is quite transparent and clear; this is usually picked out and sold at a higher price, on account of its yielding a colourless solution applicable to many purposes where colour is objectionable. Other pieces are coloured in various degrees from slight yellow to deep brownish-red, on the whole intermixed with variable quantities of straw, bark, chips, sand, and gravel, depending upon the care used in gathering it. It dissolves easily in warm water, and gives a good strong gum water at about eight pounds to the gallon. It has a tendency to go sour upon standing, which may be partially corrected by the addition of crystals of soda; but this acidity is not under most circumstances objectionable.

East India Gum, Turkey Gum.—Other qualities of gum are in the market under the above and other titles. They are inferior to good gum senegal, but they are not constant or regular in their quality. Some samples which I have seen have scarcely been fitted at all for making gum water. Instead of dissolving easily in warm water, they swell into jelly, which is ropey and gluey, not flowing smooth, something like the white of egg before it is beaten up. It is possible to use this gum, for it has been used in large quantity, but it is not to be recommended for finer kinds of work. It does not give as good shades, and it does not wash off soft. This inferior quality is best recognised by steeping the lumps in cold water, and observing if they melt away into the liquor or swell up into toughish lumps, after some hours standing. If they dissolve into clean gum water they may be accounted good; if not they may be useable, but certainly they are not worth so much as the other kinds.

Gum Tragacanth.—If gum arabic is a gum it is hard to know upon what kind of analogy tragacanth can be called a gum. It more resembles solidified paste, which resumes its bulk when it is wetted, but must be called a gum for want of a better name. It is an excellent gum for many purposes—smooth, firm, and solid—but, unfortunately for the colour mixer, so dear that he can only employ it in very limited quantity. The amount of water that it can thicken is very remarkable. At one pound per gallon it forms a mass which, in small vessels, may be inverted without running out, and at this thickness it can be used. It is dissolved by steeping it for several hours in lukewarm water, with occasional stirring. In some cases it is recommended to add nitric acid to the water, in small proportion, to be neutralised afterwards by crystals of soda; but I do not understand the benefit of it, and I question if it

does not all reside in the nitrate of soda formed being slightly hygrometric, and keeping the colour moister upon the cloth.

Any other gums which may be found in commerce will be similar to those mentioned, perhaps better than them, more likely worse. The only reliable test for the quality of gum is in making trial of it, dissolving it, seeing how it keeps, making colour from it, noting the results, and observing if it washes off easily, leaving the cloth soft and fine. It is said that natural gums have been mixed with artificial gum ingeniously brought to resemble the lumps. I have never found anything of this kind, and doubt if it would pay to carry it out at the prices gum has commanded these few years past. For some of the properties of gum not mentioned here, reference must be made to the section treating on thickening matters generally.

Artificial Gums.—Gum Substitutes.—Towards the end of the last century the natural gums, used by calico printers, became so dear as to seriously injure the trade. Many attempts were made to obtain some substitute, but with little success, the investigators chiefly looking to the gelatinous matters of linseed and mosses as the most probable sources of a substitute. The fact that heat converted starch into a gummy substance seems to have been accidentally discovered in the early part of the present century, but to whom the merit of this great boon to calico printing belongs is not generally known. There seems to be no doubt that it was a discovery belonging to these islands, and one which has done much to put calico printing in its present flourishing position. Foreign gums are now only exceptionally employed for purposes of thickening colours. The artificial gums have replaced them in the great majority of cases, for they can in general be better adapted to the requirements of any given colour than the natural gums. I have had experience in the making and using of artificial gums, and believe that they can be made to answer every purpose of thickening as well and generally better than the natural gums; economy will in all usual circumstances be greatly in favour of the artificial gums. There are very few print works in Great Britain making gums; those who do, find an advantage from it in several ways. In the United States nearly all printers make their own gums; but for the successful carrying out of this and other chemical manufactures, more knowledge of chemistry is necessary than is usually found on an English print works.

The general principle in gum making is to subject every particle of the starchy matter, whether wheaten starch, potato flour or farina, or sago flour, to the action of a high temperature. The effect of the heat is to cause a change in the structure of the farinaceous globules, so that

when put into water they burst and dissolve, while previously they were unacted upon by it. Whether the change is chemical or physical is not well known. Under the microscope the globules seem unaltered except in size. They are become much smaller in roasting, but the envelope does not seem broken; the contact of water ruptures it directly, and all dissolves into a clear liquid of a pale yellow colour. This yellow or brown colour is an inevitable result of the heat used, and in some cases it is objectionable. A French chemist, M. Payen, found that if the starch or farina was mixed thoroughly with weak acids, it required a lower heat to make it into gum, and the product could be obtained nearly white. I found that if certain acid gases and vapours were passed over hot starch and farina, they were changed into gum at a low temperature without changing the colour of the farina in a perceptible degree. These light coloured gums are employed in many steam colours, and for finishing goods. The gums which are to be found in trade are very various in their properties; the quantity required to thicken a gallon of water; and the names which they bear. Each manufacturer has his own process of mixture and preparation, and has a reputation for producing a particular kind of gum, to which he usually gives any name that he likes. Of special gums this work can take no notice, but an account will be given of what may be called simple gums, that is, gums which are genuine results of roasting the pure starches. But it must be borne in mind that most of the gums used by calico printers are mixtures made to suit the particular requirements of the style of work or the prejudices of the establishment.

Calcined Farina.—This is what its name indicates, farina or potato starch roasted or calcined to the required shade. It is the oldest form of artificial gum, and perhaps the most generally employed. Its colour is usually much darker than is necessary; calcined farina of a light buff colour dissolves as well and makes a better gum water than the very dark brown kind, but this latter is prepared more from prejudice than reason. There is a probability of a light coloured calcined farina going pasty on standing; in so far as this goes a dark coloured one is preferable, but this is a sign of carelessness of manufacture. If a light coloured calcined farina is quite soluble and remains gummy, I consider it preferable to a dark coloured one; it is more solid in the gum water, more tenacious, and gives a better mark and better shade of colour, especially with iron mordants. There is less risk of burned particles, which remain in suspension in the gum water, and cause annoyance in the printing. Calcined farina thickens at from seven to ten pounds per gallon of water; some kinds are as thick at seven as others at nine;

when ten pounds are required for ordinary thickness, the calcined farina is said to be weak. What this weakness consists in, or is owing to, is not satisfactorily known; it is not in the calcining but in the raw farina, and may be attributable to the quality of the potatoes, or to the methods of extracting the farina from them. There are weak and strong farinas in the market, which yield gums of the same kind, and the gum maker is only indirectly responsible for the difference in product. The objection to calcined farina is its expense, requiring, as it does, so great a quantity to thicken a gallon of water. It is a common custom to mix thicker gums with it, and sometimes to mix flour with it, but it is not easy in this manner to produce a good gum water. A method of testing a small sample of calcined farina is to mix it thoroughly with cold water, and place the liquid in a glass tube kept upright. In the course of a few hours all the insoluble or imperfectly calcined and raw particles fall towards the bottom of the glass, and from their bulk the quality of the sample is judged. When there is a sufficient quantity, the best test is to make a gallon or two of gum water from it, and examine when cold as to thickness, solidity, smoothness, and tendency to pastiness. For grit, pour off the top and feel the bottoms, if there are any, testing them between the teeth or between the point of a knife and piece of glass; not all that seems to be grit is so. If the lumps yield to the teeth they will most probably be charred particles of the farina. It is one of the most valuable properties of calcined farina that when hot it is so thin that all the grit can sink through it to the bottom; other gums that are thick when hot keep the grit in suspension, and it cannot be removed from them, causing much trouble in the printing. Good calcined farina keeps fluid for many weeks; only inferior qualities go thick within a month, but it is not unusual to have samples that set so hard and firm in about two days, that in colour-shop phrase, "you might stand upon them,"—a metaphorical expression for the most part, but sometimes literally true. There is something really remarkable in seeing a hot solution of bad gum as thin as water setting to a hard solid mass, when cold, which can be broken in pieces and crumbled in the hand. Some farinas do not go hard but thicken a little; these generally work thick in the colour boxes; they are actually a mixture of real calcined farina and raw farina, or farina in an intermediate state of conversion. They are only mechanically intermixed, and the thin part appears to leave the colour faster than the thick in the machine; the mass gets thicker and thicker until it becomes impossible to work it. It must then be either warmed up, mixed with thin, or, as usually happens, thrown away.

Dark British Gum.—This name was originally given to pure wheaten starch, roasted to a dark brown colour. Many gum makers sell a compound gum under this designation, containing none or only a small quantity of wheaten starch. Others still furnish calcined starch under its old name; it will be taken here as made entirely from starch. It is a stronger gum than calcined farina, thickening at about six pounds to the gallon of water; it works and keeps very well when properly made; it is better adapted for alkaline colours than calcined farina, and generally with the same strength of mordant gives deeper and fuller shades. Owing to the costliness of wheaten starch, it is the most expensive of the artificial gums. For the same reason there is a great inducement to the maker to substitute cheaper original matters in its preparation, and sometimes to dispense with wheaten starch altogether; the only point with regard to the consumer is to take care that he does not pay forty pounds a ton or so for a gum which would sufficiently remunerate the maker at thirty, under the impression that he is being furnished with calcined starch.

Light British Gum.—This was originally pure wheaten starch, which had received a very slight roasting. It had in consequence a light colour, and from not being wholly converted into gum, had a pastier nature than the dark British; it is suitable for steam colours. It should thicken at from three and a half to four and a half pounds per gallon, and should keep in working order for ten days at least. Light British gum, like dark British, is now seldom made from starch alone, but is a compound gum, containing two or more different gums.

Gum Substitute.—This is usually the same as light British; but it is a name of so indefinite a nature that it can easily include any kind of gum, and does actually serve for many varieties.

Soluble Gum.—The gum sold as soluble gum, and known also as patent light gum, de-laine gum, etc., is of a light colour, and, as its name indicates, should be easily and largely soluble in cold water. It is made by the use of acids, and requiring more time and more care than most of the other gums, is more expensive. It should thicken at about five pounds to the gallon, but it is variable, and sometimes requires as much as eight pounds to give good gum water. The solution should be clear and but lightly coloured. It is not so solid or adhesive a gum water as that made from natural gums at the same weight, nor would it answer well if it was.

There are other gums in the trade, and modifications of gum and flour sold as suitable to certain colours and styles, under various names, but which require no further mention here.

Generalities upon Artificial Gums.—The goodness or badness of a gum cannot be tested upon small quantities with any trustworthy results, nor can they be predicated from the appearance of a gum water, except by one accustomed to judge of them; for the most part the quality of gum can only be decided upon after it has done fifty or sixty pieces. A good gum will print that number without requiring to be emptied out of the box, and without being thicker at the end than at first. Sixty pieces should be reckoned a sufficient test for any gum, and a gum deserves to be condemned that will not print more than thirty without changing. A first-rate gum for madder purples will keep fluid for a month in the colour-house tubs, and, if going pasty then, will only require mixing with some hot gum water, or warming up by itself to be right again. Inferior gums go pasty in from three to seven days. It is a very bad gum that will not stand good for three days; when too thick the only remedy is to warm them up again and get them used without having to stand long. Such a gum is wasteful, and should not be tolerated, for colours made with it become thick and unfit for working, and the frequent warming is injurious, and a good deal is spoiled altogether and thrown away. Some gums froth much more than others in working, and in consequence give bad work. I could never satisfy myself as to what this froth-producing property could be attributed to with justice. It was always worse in gums made from inferior farina, i.e. farina not perfectly freed from the pulpy matter of the tuber; but it existed in gums made from very good materials. A dose of linseed oil in the gum water as it is being boiled up is the best preventative of frothing, but it does not always stop it. Some colours are more liable to frothing than others, notably, buffs from acetate of iron, alkaline pinks, and light shades of madder purple. If a moderate quantity of oil does not prevent it I know no other remedy. When the frothy colour is left to stand, the froth collects on the top, and good colour, which can be used again, settles down; but the time it requires to settle, and the quantity that will not settle at all, depends upon the kind of gum and how much it has been worked. A Twaddle is sometimes employed to test gum water, but it is of very little good; if the gum is fluid enough to let it sink as far as it will, it marks higher in proportion as there is more gum to the gallon of water; thus calcined farina at eight pounds will mark more than dark British at six pounds, although this latter may be for all useful purposes a thicker gum than the former. What the hydrometer shows is density, not thickness; and it will be found to mark higher on a solution of common salt, at three pounds per gallon, than on any gum water, at the same quantity of gum per gallon,

though one is as thin as water and the other of some thickness. An instrument has been devised, called a viscometer, for indicating the comparative thickness of gum waters. It consists of a tin tube, about an inch and a half in diameter, open at the top, and pierced with a hole about one-eighth inch in diameter at the bottom end, which is closed with the exception of this hole; it is loaded with lead at the bottom. The manner of applying it is to place it gently on the surface of the gum water, and note how many seconds it takes to sink to a certain mark; the time depends upon the viscosity of the gum, measured by the rapidity with which it enters the small hole at the bottom. In water the viscometer sinks in a couple of seconds; in thick gum water it may take seventy or eighty seconds to sink under the surface. Another plan was to measure the time a gum water took to ascend a strip of bibulous paper, like blotting paper, or chemical filtering paper, and judge of its thickness by its resistance to capillary attraction. These, and other plans, will not give much assistance in forming a correct idea of the qualities of a gum water. An experienced machine printer or colour mixer will inform himself of the value of what he is working with more effectively and truly by simply putting his hand in the gum water or colour, than by any elaborate or scientific tests or apparatus yet invented. This is the result of long working among such things, which teaches how to arrive at conclusions by a kind of instinct, or at least intuition, which seems to have no steps. Artificial gums are sometimes overloaded with grit; as mentioned under calcined farina, it falls to the bottom when the gums are thin on boiling, but in gums thickening at five and six pounds to the gallon, and possessing some degree of thickness when boiling, the grit remains in suspension throughout the mass of gum water. To ascertain whether a certain gum contains grit, and how much it contains, the following plan may be adopted. Take any convenient quantity of the gum (for a colour-shop experiment about five pounds will be required), mix this quantity with a gallon of water, in a clean copper pan, and add a gill of vitriol and a gill of spirits of salts; raise to the boil, and boil half an hour; the acids take all the thickness out of the gum, making it as thin as water: let it stand for half an hour and draw off all but the bottoms, wash the bottoms two or three times with warm water, letting them settle properly before drawing off the liquor, then dry in the pan and take out the dry bottoms for examination. If there be grit in the gum it will show here, and can be felt by the teeth; besides grit, there will be mostly a quantity of vegetable matter present, rather disguising the appearance of it. To get rid of this the whole must be made red hot on a clean slip of metal; the organic substances

will burn away, leaving the grit behind, which may be now more satisfactorily examined and its quantity weighed. It will be found exceedingly fine, passing readily through the finest sieve, actually running through dressing silk as rapidly as if it were quicksilver. At first it does not seem as if this were the grit which destroyed the face of the roller, necessitating frequent polishings in order to get clean work, and roughening the doctor edge: but, if it be tried upon a polished plate of copper it soon shows how quickly it will roughen the surface. I have never found gum totally free from grit; the very best I have ever tested contained about one grain to a thousand of gum, and this quantity never gave rise to any complaints on the part of the printers. The worst I ever tested contained about sixteen grains to the thousand of gum, and was very bad indeed, spoiling the roller before twenty pieces were printed. This grit existed in the farina and sago flour, from which the gum was made, and whatever blame there was really rested upon the maker of the farina. Upon analysing the grit, I found it to be similar in composition to the stone from which mill stones are usually made, and suspected it came from the stones used in grinding the potato pulp. Subsequent inquiry supported this assumption, but some is derived from other sources. The amount of grit which is unavoidable, I estimate at two parts in one thousand, or one five hundredth. Even the largest usual amount of grit found does not seem much in itself, about sixteen pounds weight in half a ton of gum; but if it is reckoned for gum water it arises to a serious amount. Suppose calcined farina at ten pounds per gallon, there is two and a half ounces of grit in every gallon or five quarts of gum water; and in gum at five pounds per gallon there will be an ounce and a quarter. In the case of a gum containing five grains per thousand, a gallon of ten pound farina water would contain nearly an ounce of grit. In open patterns the grit passes with the colour on to the piece; it is in closer styles that it is troublesome. There is no method of removing the grit when it is once in the gum; the most careful straining has very little influence in taking it out.

A good gum is of a very indifferent or neutral chemical character, it has little or no affinity for the various chemical substances employed in printing. It is observed that different gums give different shades of colours when the drugs are quite the same; this is usually owing to the physical, and not to the chemical, nature of the gum. The shade of colour from two different qualities of gum is usually in relation to the quantity of gum required to thicken a gallon—the less gum the darker shade—and also it is influenced by the structure of the gum when dried; if the gum dries hard and flinty, the colours are not usually so

good as when it dries porous and soft. It is for this reason that compounded or mixed gums are in many cases preferable to pure ones; a pure gum, like calcined farina, is too dense or close in its texture, when dried it is too much like varnish. A good gum will partake partly of the properties of paste, drying up porous, not so close and hard as a natural gum. A gum may contain sugar, or saccharine matters, which will interfere with the fixing of the colour and mordant, obstructing the deposition of mineral matter upon the fibre, and injuriously affecting the shade of colour produced, especially in the case of iron mordants. The gums most likely to be bad from this cause are the soluble gums, which are made by means of acids, and the light gum substitutes, which often contain soluble gum. As before stated, acids have a tendency to convert starch or farina into sugar, and it frequently happens that in the making of these light gums sugar is formed from the raw material. Its presence can be detected by the taste. Though sugar is mentioned in particular, it must be understood as including other substances, not correctly coming under this designation, but producing the same effect, and having nearly the same composition; compounds possibly intermediate between gum and sugar, possibly produced by the decomposition of the sugar itself into some more developed compound. The existence of something similar to caramel, or burnt sugar, in calcined farina and dark gums, may be easily understood from its colour and taste. Gums which enter into fermentation in warm weather generally contain saccharine matters, and are also generally made from inferior material. That fermentation can reach an extent capable of injuring the gum is very probable, but a slight fermentation does not do so. In fermenting, the sugar is destroyed and acid produced; the acid is the acetic acid, which is not injurious, in moderate quantities, to mordants or the majority of colours. According to my observation, a little alcohol exists at the same time as the acid, but it appears to soon pass away, and be changed to acid; if alcohol was present, even in larger quantities than is possible, it would do no harm.

A gum will either dissolve totally in cold water or only dissolve in part. The first class is distinguished by becoming thin on boiling, the second by going thick. A soluble gum has some advantages, and some defects, as a working gum, and can only be advantageously applied to certain classes of work. Dissolving off the cloth easily, it should be used for steam and spirit colours, and generally, in all cases where the pieces are washed off cold, less washing is required to take the gum out, and the colour is, of course, less injured. Beyond these cases, I do not see any advantage in having a gum perfectly soluble; it ought not to

be a required condition in a gum which is employed, or intended to be applied, in making colours for dyeing. The hot dunging or cleansing liquor clears off a thickening equally well, whether it be paste or gum; and though a gum thickening will be more speedily cleansed than a paste thickening, and, consequently, a soluble gum more quickly than one only partly soluble, the time required in the hot dunging liquors is greatly in excess of that required to take off the most resistant of ordinary thickenings.

Testing and Analysis of Starch, Flour, and Gum.—The various starches found in commerce are not distinguishable from each other by chemical tests; by combined microscopical and chemical testing it is possible to distinguish one species from another. There is, however, no means yet of ascertaining the relative quantity of two different kinds of starch in a mixture. A good quality of wheaten starch does not give more than one per cent of incombustible matter upon burning; if more than that is found adulteration may be suspected. I have found a sample of starch to contain 14 per cent of mineral matter, chiefly sulphate of baryta, and the worst sample I have seen contained 32 per cent of a mixture of China clay and gypsum; it was in a powdered state, and called best French starch.

Flour may be tested on a small quantity, by separating it into starch and gluten. To do this, about two ounces of the flour is to be made into a stiff mass with water, and then worked in a small current of water with the hands; the starch passes away suspended in the water, while the gluten collects round the ball, and remains in the hands. When all the starch is washed away, the remaining gluten ought to be a mass of a greyish colour, tough and elastic, permitting itself to be pulled out a few inches before tearing asunder. The starch deposited from the water should be in a firm hard cake, and of a good colour beneath the surface; the water should be nearly clear from which the starch has settled. A few experiments, with various qualities of flour, will show to the operator how far he may trust to this method. A damaged flour will soon evince itself in the state of the gluten, sometimes no gluten at all will separate. The flours which are richest in gluten are deficient in thickening power, but give finer pastes, and work more smoothly in printing.

The method of separating the fine grit from starch, flour, and gums, depends upon the power of acids to destroy the mucilaginous nature of these compounds. For a laboratory experiment a convenient quantity of these bodies is taken, say four ounces to a quart of water, and to this is added an ounce of muriatic acid, and an ounce of sulphuric acid, the

whole boiled until the mixture is as thin as water, allowed to cool quietly, and the supernatant fluid drawn off. The insoluble matter may be then transferred to a filter and washed; it will contain, besides the sand, a portion of organic matter; it must be burned, therefore, to drive this away, when it is possible to ascertain both the quantity and quality of the sandy residue.

Albumen (white of egg).—This substance differs very much, both in its origin and properties, from any of the previous thickenings. It is an animal substance, being, as its name indicates, the dried whites of eggs. It has already proved a valuable aid in calico printing, and it is only its high price which prevents its being much more largely employed. The foregoing thickenings have been called vehicles for conveying the mordant or colour to the cloth, but having once deposited it there they have nothing more to do, and the colour is either a fast or loose colour as it is able to retain its own hold of the fibre or not; in the washing or dunging the gum is carried away entirely from the cloth. Albumen is a vehicle of a different order; it is one in the sense in which artists use the term. It is a medium to hold the colour, and a varnish to fix it at the same time. When albumen colours are washed off after steaming, none of the albumen is removed; it remains as an integral and necessary part of the pigment. Until quite recently albumen could be said to have only one use as a thickening, and that was to cover or surround some pigment colour like ultramarine blue with an insoluble network of fibrous matter, which, like a transparent bag, held it attached to the cloth without the pigment itself entering into the fibres of the cloth, or into the texture of the albumen, but in reality existing between the two, or rather between a double layer of albuminous coating. Lately some colours have been introduced in which albumen acts the part of a mordant, receiving the colour, for which the cotton fibre has little or no affinity, and itself adhering to the cotton fibre just as alumina and iron act; this is the case in the new purple and pink colour from tar liquor, called aniline purple, etc., and in a shade of purple produced from a new treatment of archil. Albumen fastens simple pigment colours by its coagulatory powers, and it is a matter of common notice that the liquid white of an egg upon boiling becomes hard, solid, and insoluble in water. The same thing takes place by steaming albumen colours. Coagulation is produced: the white of egg changes its structure and becomes insoluble in water, and having tenacity and a hold upon the fibre cannot be removed by washing; at the same time it entangles the coloured powders in its meshes, and preserves them from the action of solvents. Passing albumen colours directly into boiling water seems to fix the colour quite

as well as steaming, but the latter will be more generally manageable. The power of albumen to act as a mordant is considerable, but it does not as a rule give bright or pleasing colours. Cotton cloth prepared with it, and steamed so as to coagulate the albumen, can take many colours it could not receive before, as, for example, the yellow from picric acid, blue from sulphate of indigo, and pink and purple colours from aniline. It is not the cotton but the albumen which takes the colour. Its great cost prevents its being made much use of in this direction. A good quality of albumen is recognised by its clear transparent colour, by its taste not being disagreeable, and its smell free from putrefaction. It should dissolve readily in cold water, but requires constant stirring. It must be mixed up in the reverse order to dissolving gum; instead of mixing a little water with it and then adding more, it is best to have all the water together at once, and throw the powdered albumen into it; hot water near the boil coagulates it, but water a little warm can be used to dissolve it with advantage, but it should not be hotter than 100° Fahr., or blood heat. To prevent excessive frothing, as well as to make it work smoother and keep sweet longer, various additions are made, probably not the same in two places. Ammonia, turpentine, and oil are principally what are added, but as little as possible of this kind should be put in, as it is likely to damage the albumen. For the sake of economy gum water is frequently added to the albumen solution. To a certain extent this is not injurious, but it must be kept within limits, or else it will prevent the effective coagulation of the albumen upon steaming. Sulphite of soda has been recommended as a preservative of albumen from putrefaction; it must only be employed in small quantities. Albumen liquor should be always kept in a cool place, and no more made than is likely to be consumed in a couple of days. Albumen colours are better for a few hours ageing than not. They should not be hard dried from the machine, and though they are softer and cleaner for washing off after steaming, it is not always deemed necessary.

Substitutes for Albumen—The scarcity and high price of albumen have stimulated ingenuity in discovering substitutes, but I am not aware that up to this date there is anything in the market which can be called an efficient substitute for albumen. The Industrial Society of Mulhouse has offered a large premium for the introduction of an albumen substitute which shall be less in price than the egg albumen, and as good in every respect. It remains to be seen whether this will draw out any processes available or not for the printing trade. I know it is an exceedingly difficult matter, having occupied myself some months

upon this subject, and not obtained any result fit to compare with albumen. There is a kind of albumen known as blood albumen, which is really obtained from blood; it has a dark colour and offensive smell, and is otherwise objectionable without being much cheaper than the egg albumen. It has also been proposed to extract albumen from the eggs of fishes. I was under the impression that the fibrine of blood would be likely to yield something similar to albumen; it can be obtained of a good colour, and in some places large quantities are available. I obtained some promising results from the solution of fibrine in various alkaline salts, but nothing regular and certain, and never anything to compare with albumen. The same failure attended a long series of experiments with the gluten of flour, the various vegetable albumens and fibrines in peas, beans, &c., and modifications of glue and gelatine. The attempt to use silicate of soda has been referred to under that head, and the causes of its failure explained; its alkaline nature alone would render it unfit for all vegetable lakes or pigments.

The German printers employ a solution of glue for thickening pigment colours, and then pass the pieces through alum or aluminous salt, which forms an insoluble matter round the coloured pigment and partially fixes it; but this is not to be recommended either on the score of fastness or brightness of colour. Some printers simply use starch to apply ultramarine blue; such a colour should be carefully kept from contact with water. M. Kuhlmann has found that the alkaline earths, as lime and baryta, incline to form insoluble matters with starch, and has had the idea of applying this to purposes of printing, but I think it has not been practically applied; a few experiments I made in that direction did not promise any good results. Shell lac dissolves easily in solution of borax, and can be brought to a consistency very proper for printing; this seemed to me a likely vehicle to answer, but I failed to get anything first-rate from it, for when the colour was fixed, it was so much injured by the colour of the shell lac itself, as to render it dull and unpleasant. Bleached shell lac does not dissolve in borax like the natural coloured kind. India-rubber dissolved in naphtha has been proposed as a vehicle for pigment colours, but it presents difficulties in printing; its use is attended with danger from the highly combustible nature of the naphtha, and it does not leave good bright colours under any circumstances.

Lactarine and other preparations of milk have been and are now employed for fixing ultramarine and similar colours. Under some conditions the results are passably good, but it requires an unusual amount of care and attention to make it work at all. The colour from

lactarine, which is good in the morning, may in the afternoon have changed either into a solid mass or a curdy conglomerate, totally unfit for printing, and unconvertible by any contrivance into good colour again. A lactarine colour is seldom good for more than one day, and in consequence it is a very wasteful colour, unless the quantity required is accurately known to the colour mixer ; what is not used before night is generally lost altogether. There may be qualities of lactarine to which these remarks are not applicable, but they are true with regard to several samples sent for trial by the manufacturers, and with reference to all the samples I have tried.

Drying oils have been used as vehicles for pigments, but they are difficult of application and require special arrangements and skill to make them any good ; for this reason, oil colours are scarcely ever found on calico. In some very superior qualities of French work they may be seen producing very striking effects ; but it is evident that they are applied by block upon carefully prepared grounds, and must, including the labour, be very expensive. I believe that in the course of time oil will be extensively used as a vehicle for colours in calico printing ; but several improvements or alterations in the machinery will be necessary, and some more complete and effective means of taking the quality of greasiness out of drying oils discovered. Resinous gums, dissolved in turpentine, naphtha, and alcohol, have also been employed, but the difficulties are of the same nature as in the case of oil, added also to the increased expense of this class of varnish from the dearth of the solvents.

CHAPTER XVII.

ALCOHOL—NAPHTHA—TURPENTINE—RESINS—OILS.

Alcohol.—Spirits of Wine.—Spirits of wine are very little used in British colour making at present. On the continent alcohol enters into many colours and dyes, but the heavy excise duties in England have, until lately, shut it out from nearly all manufactories. The customs allow the sale of a mixture of alcohol and naphtha at a nominal duty, which puts the printers and dyers here on nearly the same footing as on the continent. The methylated spirits would probably answer for every ordinary purpose for which alcohol is used, but manufacturers, who would at any time employ only a small quantity of this material, naturally object to laying their works open, on that account, to the visits and inspection of subordinate customs officers, whenever they choose to exercise the right. Alcohol is used to extract the colouring matter from alkanet root; it is used in printing and dyeing with the new French purple, patented under the name of Spence in this country; it is a solvent for many substances not touched by water. Nearly all colouring matters are more soluble in alcohol than in water; it can dissolve resinous and fatty bodies by the assistance of heat. It is much employed in the laboratory as a general solvent.

Ether.—This is a substance derived from alcohol; its dissolving powers are even more energetic than those of alcohol, and exercised upon different bodies. Its high price puts it out of the possibility of any extended application at present.

Wood Naphtha.—This is a liquid obtained from the distillation of wood. It bears a resemblance in its general properties to alcohol; it acts as a solvent for the same substances, and can often, but not always, be employed in its stead. It must not be confounded with coal naphtha,

used for lighting purposes; it is an entirely different substance. It mixes with water, has an agreeable, or, at least, not disagreeable smell, a hot burning taste, and burns without smoke. It is not used to any considerable extent except in making varnishes. It is mentioned here because of its solvent powers, which may, in some cases, be advantageously employed with regard to colouring matters.

Turpentine, or Spirits of Turpentine.—Turpentine is the name given to the thick viscid matter which exudes from certain trees; when this is distilled in retorts, the clear liquor, commonly called turpentine, comes over, and common rosin is left in the still. Turpentine is used in colour mixing; it is not easy to say what its chemical action is, most probably it has none at all, producing such effects as it can be shown to produce by means of its physical properties. In some cases it seems to act by preventing oxidation, in others by softening the colour, and in others as an antiseptic. In spermaceti colours it acts as a solvent, and probably in other cases it has some influence upon the colouring matter as a solvent. It dissolves the colouring matter of alkanet; it can dissolve great quantities of oil and fat, and most of the resinous substances.

Rosin and Resinous Substances.—Common rosin has become an important substance in bleaching cotton goods; its effects are remarkable, and could scarcely have been anticipated. It is the residue of the heating of the juice which flows from certain trees, the pine species in particular. It varies considerably in quality, and consequently in price; some kinds contain a sufficient quantity of turpentine, when arrived in this country, to make it worth while to distill them over again, to extract what the unskilfulness of the foreign distiller has left in. The quality of rosin can be generally estimated by a simple inspection of it. It should be clear and transparent. Its colour does not matter much for bleaching purposes, if it is otherwise good, but its transparency seems to be an important matter; if milky-looking it usually contains water, and is weak. It should not be dirty, containing bits of chips, gravel, sand, etc., for of course these deteriorate its value, however good the pure portion may be. Practical dealers lay some stress upon the absence of small specks upon the rosin, which can be observed, if present, upon holding small pieces to the light. When held in the flame of a gas light or candle, the rosin ought to melt without spitting or sputtering.

Rosin Soap.—*Prepared Rosin for Bleachers.*—Rosin combines with potash or soda to make a kind of soap, but it is not a real soap, according to the chemical definition of that substance; but the alkali causes the rosin to become soluble in water, and that solution possesses properties of the same nature as soap. The prepared rosin is mostly sent to the

bleachers ready made. It is made in two or three different ways :— firstly, by boiling crushed rosin with soda ash and water ; secondly, by boiling the rosin with weak caustic ; and thirdly, by boiling it with strong caustic soda. Whichever way it is made it ought to dissolve well in water, without leaving any sediment. It is very variable in its quality, containing an irregular amount of water, and sometimes a deficient quantity of alkali. Its appearance cannot always be depended upon as an indication of its quality, and nothing but chemical analysis will point out if there is the due proportion of rosin and soda with regard to water. It is not difficult to make ; some bleachers make their own, and more might do so with advantage, both in a pecuniary point of view and as having a more regular and reliable product. In making the prepared rosin by means of soda ash, the ash must be weak to begin with, and the pounded rosin added by degrees, as it dissolves in the boiling liquor. The quantity which ash can dissolve depends upon its strength, which is variable, but a little practice soon shows when it has dissolved as much as it can properly ; when this point is arrived at a little more ash is added, and the boiling continued until all the soap separates from the liquor, and rises to the top as a pasty mass. When it has cooled a little it is scooped off and is fit for use, the bottom liquor being mixed with water for the beginning of another operation. In making it from weak caustic the same method is followed ; if it does not rise to the surface some soda ash or common salt put in will compel it to do so. The method of making it from strong caustic is only applicable to small quantities. The following proportions and method may be adopted :—Six gallons of caustic soda, containing 14 per cent of real alkali, marking, if pretty pure, 44° Twaddle, is heated in an iron boiler until it gets near the boil, then 112 pounds of crushed rosin are added by degrees, with constant stirring, and the heat continued until perfect combination has taken place, which can be ascertained by taking a little of the stuff out and observing if it is all of one consistency, containing no visible particles of rosin, and, when put into hot water, dissolving with only a little milkiness. This process gives very good results when the proportion of alkali is right, and the boiling has been continued long enough ; it requires some care in the making, principally to prevent the rosin burning at the bottom of the pan. Larger quantities than 112 pounds of rosin can be prepared at once, but the difficulties increase, and the danger of burning is greater ; but, as the whole process does not take more than an hour and a half, it is quite easy, even with a small pan, to keep a large bleaching works supplied with prepared rosin. If the prepared rosin is short of soda, or if the combination between the

rosin and soda has not taken place in a thorough manner, the rosin is liable to be thrown upon the pieces during the bowking, in such a manner that it will not wash off; the sours fix it still more, and it remains upon the cloth to its injury, especially when the cloth is intended for dyeing. If the pieces are dried over tins, the rosin will sometimes collect on the skrimp rail in considerable quantities. I have known several ounces of a mixture of rosin and cotton fibre thus collected, and seen pieces of sound calico torn across by the half melted rosin on the bar holding them against the pulling of the tins. This can always be avoided, by increasing the amount of soda to the rosin, and attending to the heating of them together. The action of the prepared rosin in bleaching is that of a soap, dissolving the natural and added resinous matter contained in the fibre, and so loosening the dirt which these kept as it were fastened to the cloth.

Gum Thus.—This is a resinous substance of nearly the same character as common rosin. It is used in bleaching for the same purposes, and is sometimes preferred. I am not aware that it is any better than rosin; it is certainly not so highly coloured, and perhaps this may be of some use in bleaching fine goods. It seems to form a more perfect soap with alkalies, and is not so much subject to getting fast on the cloth as rosin, if it be slightly deficient in alkali. It is higher priced than rosin.

Oils and Fatty Matters.—Oils of various kinds are used in printing and dyeing to some extent, but in only one or two cases as directly connected with the production of colours; but these oils are so important in many respects as subsidiary agents, that a knowledge of the properties of the principal of them is necessary. Oils are divided into two divisions, namely, fat oils and essential oils; a fat oil being what is popularly understood under that name, its distinguishing character being to give a greasy spot on paper which does not disappear by warming; the essential oils resemble turpentine, most of them have well defined smells, they are thin and volatile, and a stain made by a drop upon paper disappears when strongly warmed. They are none of them employed in printing or dyeing, except the oil of turpentine, which has been previously spoken of. The fat oils (and by this is meant to include those solid fats like tallow, which do not take an oily consistency in this climate) are again divided into two classes, called rancid oils and drying oils, from the manner in which they behave when exposed for long periods to the action of the air. An oil which dries up or forms a skin over the surface, or that shows any inclination to thicken into a resinous substance upon a long exposure to the air, is called a drying oil; linseed oil is the best common example of this class of oils. When,

on the other hand, an oil shows no inclination to skin over or dry up, but rather to become more fluid and at the same time gives off a sour smell, and has that appearance and taste known as rancidity, it is classed among the rancid oils; some of these oils grow firmer on standing, but they never go tough or form skins. The animal fats, as tallow and sperm oil, are good instances of this class. The term "rancid oil" is not a good one, for some fats of this class do not go sensibly rancid by very prolonged exposure to the air, and probably never would become rancid; it actually means an oil which does not go thick, in contradistinction to one which does. The drying up of an oil on the one hand, and its rancidity on the other, are owing to the same chemical cause, which is the absorption of the oxygen from the air and the production of some essential modifications in the internal composition of the oil. Exposure to the air is essential to this change, for in quite close vessels the drying oils remain thin and the rancid oils sweet; but as practically all common vessels contain and admit of a circulation of the air within them, so these effects of drying and rancidity do make their appearance even in corked-up phials, but of course only when so kept for great lengths of time; so much the more do their characters appear in oil casks and in oil reservoirs: but they are in their greatest state of activity when the oils are exposed to the air in thin films, as on paper soaked in them, or painted on wood, or as lubricants on machinery. The drying oils are suitable for painting and varnish making, and quite unfit for machinery, while, on the contrary, the rancid oils are adapted for all lubricating purposes, and quite unfit for painting, never becoming dry. The chief fatty matters in use on a print or dye works are as follows:—

Tallow.—This is the melted fat of animals, and one of the most valuable of all fats; it undergoes very little change on exposure to the air, and is solid at the temperature of this latitude. It is used as a grease for machinery, either alone or in combination with other fats or substances; principally, however, on account of its not being fluid, it is employed in warm places, or warm bearings, or on large wheels. It never goes acid when good. The best kind of soap is made from tallow, but on account of the comparative dearness of this fat it is seldom used alone in soap making, but mixed with other oils of less value. The soap sold as white curd soap should be a pure tallow soap.

Sperm Oil.—This is an animal oil, and the finest and best of all oils for lubricating machinery; it is very thin, and seems to resist the action of the air for any length of time. It is the most expensive of all the common oils, and is only used for particular purposes in lubricating and for burning.

Olive Oil (Gallipoli oil).—This is perhaps the most important of all the vegetable oils, from the quantity which is produced in Europe, and the many useful purposes to which it is applicable. It is extracted from the fruit of the olive, the commercial quality being about the third pressing of the fruit, after two pressings have taken out the finer qualities used for domestic purposes. Besides the oil pure, it contains variable quantities of vegetable matter of an albuminous nature, which make it thicker and more ropy in appearance. This oil should be sweet to the taste and clear to the eye, of a dull yellow colour, and an odour free from rancidity. It is often adulterated with cheaper oils; and it is a matter of the greatest difficulty to ascertain if this is the case by chemical means, still more so to judge of the name of the adulterating oil and its proportion to the rest. Practical testing and comparing of qualities on the large scale are the only reliable means by which the value of a sample can be estimated; long experience enables a person to judge at once by the taste and smell what kind of an article is offered to him.

Gallipoli oil is equally fitted for lubricating machinery and making soap. It is not often used for this latter purpose in England, but the best known soaps of the continent, the southern countries especially, are all made from this oil. Gallipoli oil is employed by the Turkey red dyers as a preparation for the dyeing; for their use it must possess some peculiar properties not necessary to its goodness for general purposes. It must mix up thoroughly with a weak solution of pearl ash, forming a milky fluid, which must not break or throw up any oily globules for a period of at least twenty-four hours. Not all the oil in commerce possesses this property; there are means of making it suitable when it is not so, but I believe the bulk of common Gallipoli oil answers without any preparation. This property of forming what is called an emulsion is possessed by several vegetable oils, but by none in so perfect a manner as by this oil. Pure olive oil does not form a perfect emulsion, and it is supposed that the ordinary oil owes its qualities in this respect to the impurities it contains. An oil which will not mix with weak alkaline solutions by itself, will do so very readily if beaten up with the yolk of an egg, which seems to indicate that there is something of an albuminous nature in the oil. It is quite plain, therefore, that an oil very good for one purpose, would be either inferior or bad for another use. Gallipoli oil is in regular use in colour shops for mixing with colours, especially paste colours, to give them smoothness and enable them to work better; in gum colours it is used to prevent frothing.

Linseed Oil.—Linseed oil is of two kinds, the raw natural oil and the boiled oil. The boiled oil is only used in painting, and for a few other purposes where it is required to dry up into a kind of varnish. The raw oil is of a drying nature, but not so strongly marked in this respect as the boiled—the boiling being for no other purpose than to heighten its properties as a dryer, and to give it a little more consistency. Linseed oil is used in colours, the same as Gallipoli. It is usually lower in price, and there is an economy in employing it; for keeping down froth I believe it is rather better than Gallipoli. Linseed oil does not make good soap. Drying linseed oil is the basis of all paints, and also of all the attempts made to produce oil colours for printing on calico. The chief difficulty in making an oil colour fit to print on the machine seems to lie in depriving the oil of its flowing character or its greasiness; that property which causes it to spread beyond the limits of the design, and give an unpresentable appearance to the whole cloth. At the same time, nothing must be done which will injure the transparency of the vehicle, nor interfere with the hue of the colours to be employed. Boiled oil is inadmissible on account of its colour, especially for all light or bright coloured pigments. By repeatedly boiling oil in conjunction with earthy matters, it can be made into a kind of tough varnish, capable of being thinned down with turpentine, and when printed on calico not spreading beyond its proper limits. But this injures the colour of the oil for all except the darkest colours, and the use of much turpentine is open to objection. Liebig published a method of converting linseed oil into a very drying oil without injuring its colour. The process consists in shaking the raw oil up in a bottle, with a basic acetate of lead and powdered litharge, along with water, until it had been acted upon and taken up a quantity of the lead in solution. It could then be washed by shaking with water, and the lead contained in the oil removed by agitating with weak oil of vitriol. By this process a drying oil can be obtained, which is all that can be desired, as far as colour is concerned, but is deficient in other respects; it is as thin as the original oil, is quite greasy, and though it dries up pretty fast, it will run very much. The published processes take no account of an alteration of the properties of the oil caused by removing the lead which is held in solution by it. The presence of the lead is objectionable because it changes colour on the cloth, becoming brown, probably owing to the sulphurous vapours in the air, probably from absorbing some oxygen and becoming changed into the higher oxide; but its removal destroys the drying property of the oil. Without the lead it is little or no better than raw oil. To obtain a product having

greater consistency, I boiled some of the oil made by Liebig's process without removing the lead; it became coloured immediately and went worse as the heat was increased, until it was quite unserviceable. Oil from which the lead had been removed by acid behaved much as raw oil would do under the same circumstances, becoming coloured to an objectionable degree as it boiled and became thicker. All the efforts I made to get a consistent colourless oil, which would print without spreading and dry up quickly, were of no avail. Some results I obtained of a promising nature by attempts to thicken the oil with various substances, as amber, rosin, and the like, and I was convinced that sooner or later the difficulties which seemed insuperable would be overcome, and oil printing become a regular and valued branch of calico printing. It resulted from my experiments that fast colours of great brilliancy and beauty could be obtained, and I did obtain them, but by processes too delicate and too costly to be practicable. I was of opinion that the cloth, in its state of looseness of texture, was not well adapted to receive oil colours, and that it would have to be prepared—the interstices being filled up with some thickening substance, and the whole fabric made smooth and absorbent—not for a permanent state, but for the application of the colour, and while it was being fixed, to be washed off afterwards.

Other drying oils are *poppy oil* and *nut oil*; they are more expensive than linseed oil, but not too much so to be capable of being used in calico printing if their properties were particularly valuable. They are used by artists as drying oils.

Palm Oil.—This valuable product comes from the African coast; it has received its name from the tree whose fruit yields it. It is called an oil because it is fluid in the tropical climate where it is extracted. It is not used to any considerable extent by dyers or printers unless they make their own soap, and for this purpose it answers better than any other fatty substance. It is easily saponified, and suits very well all the needs of the printer and dyer of calicoes and woollens. It has a strong yellow colour, of which it can be deprived by many processes, and brought into a white state, when of course soap made from it is white, while the soap made from unbleached oil is yellow.

Cheaper fish oils, as *cod oil* and *whale oil*, are not much in favour on account of their odour, which is very persistent, adhering to cloth through all kinds of processes, and making itself sensible to the smell in a disagreeable manner. They are employed in making soft soap, whence the odour of that substance is derived.

Glycerine.—Glycerine is a substance contained in all oils, with

hardly an exception; it is looked upon as necessary to their constitution. It is in its properties very different from oil. It has an intensely sweet taste, mixes with water, and might be taken for a syrup of sugar, only it does not dry up, always remaining fluid, and having a thick oily appearance when strong. Until a few years back it was very rarely to be found, except in a laboratory; but now it is an article of commerce, and extensively used in medicine and the arts. It is still expensive in England, but in France much cheaper. If it were required in large quantities, it could be procured at a much less price than it now obtains. I believe it could be applied with advantage in calico printing, especially as an hygroscopic body, or rather as a water retaining substance. Calico which has been impregnated with glycerine mixed with water does not dry harsh, it remains soft, supple, and flexible. Glycerine communicates the same property to colours, whence its possible utility will be apparent to colorists. Glycerine is a more powerful solvent for some bodies than water. I made a series of experiments to ascertain its action upon colouring matters. I found, as a rule, it dissolved them in greater quantity than water, more while hot than it could retain when cold; but it is not a powerful solvent compared with alcohol or naphtha, and will never be of any use for that purpose. The preparation of glycerine cannot be undertaken with success on the small scale.

Generalities upon Oils.—Every oil has its acid, and also its base; it may be, therefore, looked upon as a chemical salt, such as sulphate of soda is, the acid neutralising the base, and both together forming the oil or fatty compound. Glycerine is the common base for most of the oils. The acids are more numerous and distinct in their appearances and composition. It will be sufficient here to state that most of the solid fats have solid acid, called stearic acid, and most of the liquid ones have a liquid acid, called oleic acid. The majority of fatty bodies have more than one fatty acid, some have several. These acids in the pure state are crystalline, for the most part, and have decidedly fatty characters; melting into clear oil by heating, burning with a luminous flame, feeling greasy to the fingers, staining paper, etc., in fact every thing which characterises solid fat. Their acidity is very feeble in its character, but still distinct; they hardly ever neutralise potash or soda in a perfect manner, but they do combine with them in definite quantities forming real chemical compounds, which are known as the stearate of soda, oleate of potash, etc. The knowledge of these facts is necessary to the clear comprehension of the theory of soap making, and the understanding of the properties of the various substances sold and used as soaps.

The drying property of certain oils makes them entirely unfit for lubricating purposes. Manufacturers must be familiar with the thickening of the oil on bearings, and all the inconveniences it brings with it. The tendency of oil to go thick upon exposure cannot be ascertained previously with any degree of certainty or confidence; the oil testing machines are not to be relied upon, because the oil may be good, thin, and smooth when applied, and yet, in a few hours, become so thick as to prove an impediment to the motion of the machinery instead of an assistance. An attempt to economise in this direction, by using cheaper oils, often recoils with a double expense, for what is saved in the oil bill goes twice over in the coal account. Perhaps the only reliable test for the oil is to try it practically on a shaft, observing minutely its appearance and behaviour. But when small quantities and several samples have to be tested this method cannot be pursued. Some idea of the tendency of an oil to go dry or thick may be formed by spreading it very thin on a glass plate, and leaving it in a moderately warm place, free from dust, for three or four days. At the end of that time it will have undergone a change if it is of a drying nature, becoming sticky, and not flowing readily when the plate is inclined. A method recommended, and which seems calculated to give good comparative results, consists in having a smooth iron plate placed at a small inclination, broad enough to admit of as many divisions as there are samples of oil; these divisions may be made by glueing slips of wood the whole length of the plate, or in any other convenient way. A certain weighed quantity of the oil is then placed on the higher portion of the plate, down which it runs by its own gravity, and it is according to the distance traversed in a given time by a sample that its value is estimated. Such a quantity of oil must be used, and such an inclination given to the plate, as will require several days for the best oil to reach the lower edge. If the arrangement is such that best sperm oil just reaches the bottom in four days, other oils will reach it in five, six, or seven days, and some never get down at all, owing to their becoming thick on the plate. This plan, though ingenious, does not place the oils under the conditions which they have to meet in practice. I made a trial of it, but the results were absurd, and if it was to be depended upon alone it would lead to the falsest decisions; but I consider it may give valuable assistance in forming an opinion. It must only be used for comparing the same kind of oils,—different qualities of sperm oil for example, or of other oils, one against the other, but not two different species of oil in opposition, for the chance is quite equal that the best will show as if it were the worst, and the worst as if it were the best.

Various additions are made to lubricating oils and grease, sometimes with a view of adapting them to certain conditions, but oftener with a view of substituting some cheaper material for the oil. Mandrels of printing machines get very hot occasionally from not fitting the boxes well, and so, heating the roller, become a grave inconvenience. A mixture of brimstone, or flour of sulphur, with the tallow, is said to lessen the heating very much. Hot bearings, produced by great weight or bad fittings, are said to be cooled by mixing white lead with the oil; and a composition sold, and highly valued, for the same purpose, was analysed by me, and found to consist, besides tallow, of sulphuret of antimony, white lead, acetate of lead, and a little common salt. The action of these compounds is chemical: the sulphur acts upon the brass steps to form a film of sulphuret of copper; the lead and antimony compounds are under the same circumstances partially decomposed; some of the metal seems to be reduced, and interposed between the iron and brass, giving a film softer in nature than the metals it covers, which prevents contact between them, and in consequence the violent friction subsides, and the heat with it.

The part which oil plays as a mordant will be treated upon in the chapter upon mordants.

Spermaceti.—This is an animal fatty matter, obtained from a species of whale. It is not exactly an oil, although possessing many properties of oil; it mixes with oils and turpentine. It is sparingly used in colour mixing for some colours, especially for a black which has a logwood basis. It gives brilliancy to colours, and is rather more manageable than other fatty bodies when mixed in colours.

Bees' Wax, which was formerly used as a resist, is now seldom employed. On specimens of calico printing which come from India the wax resist may be seen yet. It acts as a resist, and effectually so, in all cases where the liquors are not hot or strongly alkaline; it is a resist of the mechanical sort.

Action of Sulphuric Acid upon Oils.—When strong oil of vitriol is mixed with a fat oil, and left in contact for some hours, it causes a change to take place in the oil, which can then be dissolved in water. This method of treating oils, for applying them to dyeing, has been patented by more than one party, the patents being yet in force. The object of the inventors has been mostly to shorten the Turkey red process, but what degree of success they have met with I do not know.

CHAPTER XVIII.

SOAP—GLUE—BRAN—URINE—COW DUNG.

Soap.—Soap is a combination of a fatty matter and an oxide, but the name is usually applied to the compounds of fatty matters with potash and soda only. Soap is manufactured by heating together some fat or oil with dilute caustic alkali, until they coalesce into a homogeneous mass. There is no real difficulty in making soap, and it might be frequently made by the consumer to advantage; many printers make their own soap, and where much madder work is done the economy is conspicuous. The most valuable soap is made from tallow and olive oil, but a cheaper and excellent soap for dyeing and clearing purposes is made from palm oil; the strong yellow colour of the unbleached palm oil is not found to be any disadvantage in its use for madder work, or for bleaching woollen or delaine goods. For use on print works, a soap may be made by boiling in an iron pan palm oil and caustic soda at 16° Twaddle, in the proportion of about two and a half pounds of caustic to one of oil. Combination takes place in two or three hours; upon cooling the mass sets as a soft yellow solid, which is very suitable for dissolving rapidly in the becks on account of the large amount of water it contains. This soap contains all the glycerine of the oil, as also whatever impurities there may exist in either the palm oil or the caustic soda. It answers very well for all uses on a print works; but its peculiar method of manufacture requires a nice adjustment of the quantity of oil and alkali, and is not likely to be successfully carried out without some chemical knowledge.

Soap is used in bleaching silk, some qualities of woollen and some fine kinds of cotton goods. It is used in several cases of dyeing, either to soften the water or to modify the shade of colour, especially in silk

dyeing. It is much used in madder styles, and very generally employed as a final operation to modify dyed colours and to clear white grounds. The detergent action of soap depends upon its power of dissolving or rendering fatty matters emulsive and removable by water. Dirt may be defined as dust, with some oleaginous matter, which renders it adhesive; the grease or fat being acted upon, the dust is easily removed by water. For simply detergent purposes very alkaline soaps may be employed, such as the rosin soap used in bleaching, or common soft soap; but when the action is of a mixed nature, as upon dyed goods, the soap must be of a mild, neutral character. Soap may be bad or defective by being deficient in alkali, or by having it in excess. A good soap for finishing madder work should be slightly alkaline; it is more economical than a pure neutral soap, and gives as good or better results. If the soap be too alkaline, it acts harshly upon madder colours, impoverishing them, especially the reds, while the lilacs and purples are turned to a disagreeable reddish hue. Pinks soaped with a too alkaline soap will be flat and dull, without bloom; catechu drabs and browns will be much deteriorated. Work thus injured may sometimes be improved by passing in water made sour with sulphuric acid, washing and re-soaping. If a soap is deficient in alkali it takes a greater quantity and longer time to effect the clearing of goods; frequently the whites are left dull, and a general aspect of flatness pervades over the colours. Such a soap is improved by adding eight or ten ounces of soda ash to the water before dissolving the soap in it. An alkaline soap, on the contrary, is improved by the addition of muriate or oxymuriate of tin in small quantity to the water. If soap made from a strong smelling oil be used in madder work, the finished pieces will retain the smell in a very persistent manner. I made a large quantity of soap from linseed oil, which answered very well, but was objectionable on account of the smell of paint which the pieces emitted when kept in the warehouse; cod oil and whale oil are objectionable on the same account. As a rule, any smell which is possessed by oil applied to the pieces is retained by them, and especially by delaines and woollens. An instance came under my notice of an oil introduced as a substitute for Gallipoli; I examined it and reported unfavourably of its qualities,—it was a product of distillation and contained many bad smelling oils. Its cheapness caused it to be used, however, and in a few days the delaines were complained of as having a disagreeable smell—they were returned from the warehouse as unsaleable. There was no clue to the cause of the smell; the pieces were washed, winced, and dashed, without removing the odour, and the fault was variously laid upon the gum, the water,

the steaming, and the drying. As soon as the pieces were submitted to me, I recognised the odour of one of the oils separated in the course of my analysis of the new oil. Upon inquiry it was found that it had been used in the colour mixing; Gallipoli being again used, the cause of complaint disappeared.

Soft Soap.—Soft soap is mostly made from potash instead of soda; but there are many oils which give soft soaps with soda, the fish oils particularly. Soft soap is always a stronger and harsher soap than the hard soaps. Inferior oils are mostly consumed in making commercial soft soap, but very fine neutral soft soaps can be made if proper care is taken, and sufficiently pure materials employed. I analysed a very good soft soap made from olive oil. It answered very well for delaine bleaching, but was expensive. There are some cases where a soft soap might be advantageous, if it was equally as good as a hard soap. Common soft soap is used in a few cases of colour mixing; it serves to dissolve annatto, and to make some resists. It should not be used in soaping for any delicate colours. It may be employed in moderation for brightening indigo colours, as China blue. The quality of soft soap is thought to depend in some measure upon the existence of white particles diffused through the mass, producing the appearance called “figgy,”—but this is no real test of its quality; first-rate soaps are sometimes quite uniform, and the figged character can be communicated to an article of an inferior nature, containing glue and other useless matters.

Substitutes for Soap.—Since the excise duty was taken off soap a vast impetus has been given to the trade, and a large field opened to the ingenuity of soap makers, who are now allowed to put anything in their pans, and if it only looks like soap to sell it as such. A great number of patents have been lately taken out for adulterating soap with substances more or less hurtful to it. The result is the disappearance of soap, properly so called, from ordinary use, and the substitution of waxy compounds of glue, rosin, ground bones, gelatine, earthy matters, and similar substances, having but little soap mixed with them. Such cheap substitutes as the printer or dyer is likely to have offered to him will be of this nature, and likely to prove more beneficial to the maker than the consumer. So much damage can be done by the use of a bad soap that the printer ought to insist upon being supplied with a soap which contains nothing but water, soda, and fat. Anything else will be only an addition of weight without value, and likely to be hurtful or useless. I have made many experiments upon substances similar to soap, with a view to substituting them for it, but with no notable success; it seems

to be fatty matter which is wanted, and nothing else will do. I found that animal black could be made to clear the whites of madder work, but it left the colours very dull and poor, and even soaping afterwards would not restore them to a proper shade. All alkaline substances, as the carbonates of potash and soda, ammonia, the alkaline borates, silicates, and phosphates, give bad and worthless results without soap. The only way in which soap can be saved with advantage to the work is in adding a little soda ash to the water in the beck if the water is hard: sometimes a beekful of water will destroy a pound or more of soap in precipitating the lime; eight or ten ounces of soda ash, added before the soap goes into the beck, will frequently save this.

Analysis of Soap.—The usual test for soap is to try it upon madder work comparatively with a good quality. With care good results may be obtained upon small quantities of soap—say half an ounce—but when a sufficient quantity of material is at disposal the trial should be on the large scale. The following method may be pursued in the analysis of soap—it gives sufficiently close results for technical purposes, and does not take much time. In all genuine samples of soaps there will be nothing but water, fatty matters, and alkali. The water can be determined by taking 100 grains of the soap and heating it in a porcelain dish, with a gentle heat, until all the water is dissipated; the heat may be pushed as high as 260° Fahr., or until the dry soap begins to exhale an odour of fatty matter; this will take about fifteen minutes, and give more exact results than a water bath or oil bath, which would require as many hours. For the determination of the alkali another hundred grains may be dissolved in about three ounces of water, and an excess of dilute sulphuric, of a known strength, added to it; there should be about twice as much acid added as would be necessary to wholly decompose the soap. The solution containing the liberated fatty matter must be kept hot until all milkeness has disappeared, and the oil floats clearly upon the top; then a weighed quantity of pure beeswax (about fifty grains) is added to the solution, and all kept hot until the wax is completely incorporated with the fatty matter,—the whole is then allowed to cool. Upon cooling, the wax solidifies along with the fatty matter, forming a well-cohering cake, which may be removed from the liquid, washed with a little water, and the washings added to the original solution, then carefully dried and weighed. The excess of weight above that of the beeswax employed is the quantity of fatty matter present. A graduated alkaline solution is then added to the first liquid until it is neutral; it is found how much of the acid first used was neutralised, and the amount of alkali calculated from that.

I append a few analyses of soaps, hard and soft, which have been used in the trade in the neighbourhood of Manchester :—

	FATTY MATTER.		ALKALI.		WATER.
Soft soap, made from cod oil	42	.....	8.25	.....	47
„ origin unknown.....	37.5	.....	8.81	.....	44
„ good commercial, figged	36.75	.....	9.57	.....	47.75
Linseed oil soap, broken by salt...	54.50	.....	6.50	.....	39.0
Hydrated palm oil soap, not broken	28.50	.....	3.5	.....	63.5
Hard yellow palm oil soap.....	56.60	.....	7.20	.....	36.0
Hard olive oil soap	68.80	.....	7.50	.....	23.70
Another sample, same	64.27	.....	7.73	.....	28.00

Glue, Gelatine, Size.—Glue, or size, is made from refuse animal matters, as bones, skins, &c. It is employed in printing and dyeing to a limited extent, but largely in finishing. In printing it is used as a thickener in some few cases, and enters into the composition of some resists. In dyeing it is employed in conjunction with what are called astringent substances, or substances that are in part, but not essentially, composed of astringent matter. It serves to protect the white and assist in the regularity of the dyeing. This use of glue or size depends upon the property which it has of forming an insoluble compound with that species of dyeing substances, as will be more particularly explained further on. By so doing it keeps the astringent substance from combining with the unmordanted fibre and tinging it with colour, while the mordanted fibre can dye up just as well from the insoluble substance as from the soluble. Size is used in cases where there is no astringent or tanning substance present, but in such cases I think it is unnecessary. It is an useful or essential ingredient, where sumac or galls are used as in ordinary garancine dyeing; but when garancine is used without sumac, I do not think that size is of any use. Such was the conclusion made from careful experiments to ascertain if its addition improved the result or not. Glue is sometimes used on print works in the solid state, and dissolved as it is wanted; but generally it is used in the state of size or liquid glue, as being cheaper and more convenient. Of solid glues there are different qualities with regard to their power of dissolving in water and keeping in a fluid state. Some kinds, when dissolved at the rate of one pound per gallon of hot water, go firm and solid on cooling; others may be dissolved at the rate of three pounds per gallon of water, and be only thick gummy fluids on cooling: the commercial size is of this nature. The best way to test the value of a liquid glue is to ascertain how much solid matter there is in a gallon of liquor. This can be partly estimated by its strength, as shown on the glass, but more cor-

rectly by evaporating a known weight down to dryness and weighing the solid matter. At the same time it should be examined for mineral matters, of which only a small amount are naturally present, but which might be added as an adulteration to deceive with regard to appearance of strength. I have found the following results:—

	WATER.	DRY GLUE.
No. 10 sample contained.....	68	32
No. 22 sample contained.....	70	30
No. 8 sample contained.....	65	35

Bran.—This substance has received some applications in dyeing and printing of a peculiar kind. Being derived from wheat it partakes in some degree of the nature of flour, and contains the same elements. It is not easy to say upon what principle contained in the bran its qualities depend; probably not upon any single constituent, but upon the whole, partially attributable to its soluble and chemically active matters, and partly to its insoluble particles acting in a mechanical manner. M. D. Koechlin-Schouch, of Mulhouse, considers the mucilaginous particles as those for which bran is valuable in clearing dyed goods; he found flour was not of the least use as a substitute for it, and that coarser bran was weight for weight more effective than finer bran. It seems probable that in the bran there is an oily mucilaginous matter, which acts as a weak soap in taking off loose colour, and that the woody part of the bran receives this colour and keeps it from dissolving in the water. Spent bran, used for clearing, gives up its colour to weak potash lye, showing that it has retained some colour. The principal use of bran is in clearing some styles of dyed work: garancines have been cleared in it, logwood blacks are cleared in it, and many colours receive a bran boil, as well to brighten the shades as to clear the whites. For usual purposes the bran is just scalded with hot water and put in the beck, but for some shades only the liquor must be taken, leaving the solid bran. Bran added to dyes modifies their shades in a considerable degree. For a long time madder pinks were produced by adding a large quantity of bran to the madder in dyeing; the results were pretty good, but were superseded when it was discovered amongst the Turkey red dyers that acids and salts of tin could be made to change the common red to a pink shade. Bran readily enters into a state of fermentation, becoming acid, when its properties are somewhat different from the unfermented bran. Most of those styles of work which were formerly cleared with bran are now cleared with solution of bleaching powder, practice and the diminution of prejudice permitting it to be used without danger and with much economy of time and cost.

Gluten.—This substance, several times mentioned, can be obtained from good wheaten flour by making it into a stiff paste, and then working it with the hands in a current of water; the water carries away the starch and soluble matters, leaving the gluten as a tenacious and partially translucent mass like putty. Many attempts have been made to utilise gluten in calico printing, but as yet unsuccessfully. Mr. Crum has recently patented a modification of it as a substitute for albumen.

Urine.—Urine is of very ancient use in connection with dyeing, and is yet employed, but not to the same extent as formerly; because for many of its uses substitutes were found in chemical drugs, which, if not cheaper, were more regular, more easily kept, and pleasanter to work with. Fresh urine is of no use for the dyer's purposes; it is only when it has been kept for some time, and that a fermentation or putrefaction has commenced, that it begins to possess the properties on account of which it is valued. In this state it is called lant. Urine contains a substance known as urea; it is a crystalline matter neither acid nor alkaline itself, but of a basic nature, combining with acids. It is of a complex composition, and its elements are so arranged that it takes very little to change their order. This is done by the fermentation which naturally commences in urine, and all the urea is changed into carbonate of ammonia, which, remaining in the liquor, communicates to it its soapy or alkaline properties. The strong smell of old urine is due to this carbonate of ammonia, which is in composition the same as ordinary smelling salts; and if the smell of old lant is not quite so agreeable as these salts, it is because there are animal matters of another nature present in it, which mix their odours with that of the ammonia. Lant is therefore of an alkaline nature, and its action upon substances can be partly predicated from that knowledge; it will tend to neutralise and kill acids, and generally to act as a weak solution of crystals of soda would. It is employed in bleaching wool, in several cases of dyeing to modify and change the shade, and to moisten dyewoods with before using. It is used to develop some colouring matters, as those of archil, litmus, and cudbear, and is still employed in the composition of the indigo vat.

Uric Acid.—This acid may be mentioned in connection with urine, because it is very frequently present in it, but always in small quantities, except in cases of disease. It is not worth while extracting it from urine, but it can be obtained in good quantity from the excrements of birds and serpents. Guano, in a genuine state, contains a good deal of uric acid, and the white excrement of the boa constrictor is a nearly pure compound of uric acid and ammonia. Uric acid has created a high

interest within these two or three years, on account of a splendid purple colour which can be obtained from it, and which has been applied to some extent upon silk, wool, and cotton. The colouring matter is called murexide, and will be treated of amongst the other colouring matters.

Cow Dung.—This substance has been used in dyeing for a very long period, and has had ascribed to it numerous virtues and excellencies, which modern dyers do not altogether recognise as belonging to it. Its use has very much declined since the introduction of chemical substitutes; but it still holds a place, and probably will do until some better market is found for it, in which case the trade will be very well able to dispense with it. It is employed principally in clearing or cleansing mordanted pieces before they go into the dye-beck; it is also used as an addition to some dyes; it is employed to clear the whites of some styles, as garancine; and is generally reckoned a capital thing to clean vessels or becks which have been in disuse for some time, to make them ready for dyeing again.

A great number of theories have been broached to explain the use of cow dung, and analyses have been made to show what the exact principle was for which it was employed, or in which its virtue resided; but these efforts have not been successful in producing any explanation generally acceptable to persons acquainted with the subject. The only conclusion that will be supported by common sense is that its virtues reside in the mass, that they are not peculiar to it, and that a good number of artificially prepared substances possess the same properties without containing any of the same elements. All the theories of animalisation of fibre, action of bubuline, influence of musk, etc., which have more or less obtained amongst chemists, may be put aside, when silicate of soda is found to produce the same effects; which, being made at a white heat, cannot be suspected to contain any of these supposed essential constituents of cow dung.

There have been many analyses of cow dung published, but they are manifestly imperfect, and differ considerably from one another. The excrement of an animal varies frequently in its composition from many causes, as state of health, kind of food, season of the year, etc.; the variations among a number of animals will be consequently still greater. It would require a long and tedious series of analyses of this excrement, under various conditions of health and feeding, before anything like a reliable average composition could be arrived at. Thaer and Einhof made an elaborate investigation into the composition of cow dung, though not with any reference to its uses in printing and dyeing. The excrement of stall-fed cattle contained about twenty-eight per cent of solid substance, of which the greater portion was a yellow fibrous matter,

which possessed the properties of the fibrous matter of plants ; there was also about twelve per cent of a peculiar slimy substance, to which the colour and smell of the feces are due. The filtered liquor passed through colourless, but, on exposure to the air, became immediately yellow, and then brown. This change of colour leads to the belief that oxygen was being absorbed. Further on it will be seen that I consider the uses of cow dung chiefly attributable to the fibrous matter, and some substance having a deoxidising action in it.

The following analysis of cow dung is by Morin :—

Water	70.00
Bubuline	1.60
Bile	0.60
A greenish coloured resin, with fatty acids, viz., butyric, oleic, and margaric	1.52
Albumen	0.40
Fibrous matter	24.08
Saline matters, including carbonates, phosphates, silicates, chlorides, ammonia and iron	2.00
	100.00

CHAPTER XIX.

FIBROUS SUBSTANCES: COTTON—WOOL—SILK—ACTION OF CHEMICALS UPON THEM.

CHEMISTS recognise under the name of lignine a matter which is looked upon as the basis of all fibrous substance of a vegetable nature. It can be obtained from wood by treating it successively with ether, alcohol, water, acids, and alkalies, in order to remove all soluble substances. It finally remains as a white substance of regular composition, which is the pure fibre of wood, and stands as the type and representative of all other vegetable fibres. It is composed of carbon, oxygen, and hydrogen, in proportions which give little clue to its internal composition, and its behaviour with chemical bodies is so little marked by the expression of affinity in any direction, that it can only be put down as an indifferent substance, forming no combinations or chemical compounds. Lignine is of no importance, except in a scientific or theoretical point of view, as showing that in all vegetable matter there is a substance of a fibrous nature, and that it has everywhere nearly the same chemical composition and properties. Flax and cotton, along with a great number of other substances of less repute extracted from vegetables, are of the same chemical composition as lignine, when, like it, they are purified from the resinous colouring matters which naturally adhere to them. In our remarks upon fibrous substances, cotton will be taken as representing all the vegetable fibres, being by far the most important of them, and all the others possessing nearly the same properties and characteristics.

The animal fibrous substances, of which the principal are wool and silk, do not appear to have any common origin of the nature of lignine; they are very complex in their chemical composition, and besides the carbon, hydrogen, and oxygen contained in vegetable sub-

stances, they have also nitrogen, and some of them sulphur apparently, as an integral portion of their structure. In order to bring together, as nearly as possible, the chemical and physical properties of fibrous matter, cotton, wool, and silk will be treated together, and their chief characteristics, and the action of the same chemical agents upon them, studied in juxtaposition.

Cotton, as is well known, is a woolly substance, taken out of the pod of certain species of plants growing in many parts of the world. It consists of a number of fibres, which being straightened by machinery and twisted together, form threads. Each single fibre is exceedingly small in its dimensions; the length of the fibre is various, being much longer in some varieties than others, and constituting then the finer and more valuable cotton for spinning purposes; the diameter of the fibre also varies, being less in the finer kinds and greater in the coarser. Coarse cotton used for candle wick has a fibre $\frac{1}{800}$ of an inch in diameter. In the finest kinds of cotton the diameter of the fibre does not exceed the two thousandth part of an inch. According to the microscopical investigations of different observers, the fibre of cotton, when magnified, appears like a ribbon flattened and twisted; and another observer says that the fibres are evidently hollow tubes which have collapsed, the sides coming together forming a furrow in the middle with raised sides, giving it a triangular appearance, or, as others have expressed it, fluted or ribbed. Cotton in its natural state is sometimes quite white, and others more or less coloured; some kinds are naturally so yellow as to constitute, without any dyeing, a coloured fabric called nankeen. This colouring matter does not appear to be a portion of the fibre, but only an accidental addition which can be removed without injury to it.

The fibre of wool is different in many respects from that of cotton. Its quality varies greatly; its length is between three and eight inches, and the diameter of single fibres is from the thousandth to the fifteen hundredth part of an inch. Under the microscope it appears as a tube, circular and hollow, and at intervals, of which there are three hundred in an inch, are seen rings or projections in regular order, which, in arrangement, have been compared to the scales of a fish, the skin of a serpent, or as if a number of hollow cones were placed one inside of the other. It is as if the growth of wool were not in one even, constant progression, but more rapid at one time than another, the concentric rings representing a state of rest or inactivity, which follows on the active period. Several peculiar properties of wool are attributed to the presence of this kind of fibre,—the felting or adhering together of fibres of wool, the harshness which is felt by the finger or lips when a fibre of wool is

drawn in one direction but not in another; a property stronger in hairs than in wool, but the same in character and origin. In working woollen cloths, they are, as is well known, liable to run up, contract in certain dimensions, becoming thicker at the same time. This is what takes place purposely in fulling, and accidentally in too much or too roughly handling woollen goods in washing and dyeing; such runnings up are familiar in domestic economy. They are attributable to this construction of the fibre of wool; each fibre may be looked upon as barbed like an arrow or a fish hook, easily going in one direction, but not able to return on account of these projections holding it, and generally all kind of motion among the fibres, as rubbing, beating, or stamping, causes them to advance in the direction of the small end of the cone, and remain there unless pulled back by force. In woollen goods, and muslin delaines much injury may be done to the general appearance of the cloth and goodness of the colours if the pieces are too roughly used, or allowed to remain loose when in a wet state.

Silk is entirely different from either cotton or wool, being the production of an animal forcing a gelatinous substance from its body through a fine opening into the external air, where it solidifies. There is more resemblance to a wire drawing process than a slow natural growth. The fibre of silk is consequently of very great length. Under the microscope it presents the appearance of an uniform thin thread, without any signs of structural organisation. The diameter of a single fibre is about the two thousandth part of an inch; it is the strongest of all the fibres.

Cotton in its native state is nearly pure, being contaminated with only a little colouring matter; it does not lose much weight in being made into thread or cloth. Wool contains, in its natural condition, a large amount of grease, which serves an useful purpose on the animal it protects, but which has to be removed before it becomes a manufactured article. This greasy matter, removable by bleaching, will amount usually to one quarter of its weight, and may be as high as one half of it. Silk, as it is obtained from the cocoon, is impregnated with a gummy substance, which amounts to about one quarter of its weight, and has to be removed before it can receive colours.

ACTION OF CHEMICALS UPON FIBROUS MATTERS.

Action of Acids upon Fibrous Substances.—Weak acids have no special action upon cotton. If cotton be steeped in sulphuric acid, or any other acid, weakened by water until it does not act injuriously at once, it may remain in contact with it for almost any length of time

without being injured. If the cotton cloth, which has been steeped in a dilute mineral acid, be placed in any situation where it will become dry, in proportion as the water leaves it the acid gets more concentrated, until it becomes strong enough to act upon the cloth and rot it. The same remarks are applicable to wool and silk. Heated dilute acids act differently than when in the cold state, being, as is usually the case with hot liquids, more powerful than cold, and a strength is soon arrived at where acids do act destructively upon fibres; but it is not the same for each of the fibrous substances treated of. Cotton is the soonest affected, and wool the last, silk holding an intermediate state. An acid liquor which would rot cotton in a short time will not injure wool, nor act much upon silk, the animal fibres not being so soon broken up by acids as the vegetable. This property is taken advantage of in separating wool from cotton in worn mixed fabrics; the whole fabric is steeped in dilute acids, wrung out, and dried in a hot stove: after a certain length of time it is beaten with rods, all the cotton flies off as dust, being corroded and disorganised by the acid, while the woollen threads are not perceptibly injured in strength. It does not appear that dilute acids, though they may destroy the structure, alter the chemical composition of vegetable fibres, the powder to which the fibre is reduced being cotton just as much as before. The action must be of a physical or mechanical nature. It is easy to suppose a single fibre of cotton as consisting of a vast number of small particles laid in a row, and held together by some kind of mechanical adhesion, by fitting into one another as it were, or sticking together by power of contact. The acids may interfere in some unknown manner to loosen this adhesion, when the particles will fall asunder, still remaining the same in chemical nature, but wanting the bond which made them into a fibre; as a machine may all fall to pieces by the loosening of a screw, and become a heap of iron, still iron, but no longer a machine.

Of the principal acids in use among bleachers and others, the muriatic acid, or spirits of salts, seems to be the most energetic, for its strength or degree of acidity, in disorganising fibre; and in cases where it is employed special care should be taken that pieces are not exposed to chances of drying in the places where they are laid before washing off.

Action of Strong Acids upon Fibre.—Cotton can be dissolved in strong oil of vitriol if added in small portions at a time, being dried previously; it forms a gummy solution, not going black; when water is mixed with it the cotton falls out as a white powder, which appears to contain some of the sulphuric acid in combination with it. If heat was applied to the gummy solution, or if the liquor was to become hot by mixing too

much cotton at once, it would go black, and give off fumes of sulphurous acid, changing the cotton into a black charcoal. If cotton be put into a mixture of equal parts of vitriol and water it can be dissolved, and in this case it is changed into grape sugar. If cotton cloth be quickly passed through a cold mixture of oil of vitriol and water, at about 140° Twaddle, it is not injured, but somewhat strengthened. This was one of the processes for Mercerising cloth.

Muriatic acid destroys the fibre of cotton without blackening it; there are cases in which it does blacken it, but that is only when a high temperature has been employed, or when the acid is impure. This acid, it will be remembered, is only a mixture of an acid gas with water, and it cannot be made above a certain strength; that is, in the strongest liquid acid there is only one part of acid by weight to two parts of water. It has not, therefore, the strong action of sulphuric acid upon cotton, and a drop of the strongest spirits of salts may be applied to calico, or calico may be steeped in spirits of salts for some time without being destroyed, but it must not be exposed to the air. (See page 70).

The action of nitric acid is different in kind from that of the other two acids. The very strongest acid, standing at 100° Twaddle, converts cotton into an inflammable substance (gun cotton) without much injuring its strength as a fibre, and not at all affecting its appearance. It acts in the same manner if mixed with about an equal part of strong vitriol. Such a liquid acting upon paper converts it into a tough horny substance resembling parchment, which, in some respects at least, is very much stronger than the original paper. In the case of gun cotton, the cotton itself is no longer simply the vegetable substance which it was before the action of the nitric acid; when analysed it is found to contain nitric acid, or the elements of nitric acid, in some peculiar form of combination with the vegetable matter, the weight being increased thirty or forty per cent by the steeping in the acid. M. Kuhlmann is of opinion that by steeping cotton cloth in mixtures of nitric and sulphuric acid its affinity for colouring matters is much exalted, and he has partially proved this, as I had the pleasure of seeing some specimens when he was in Manchester; but it is a question only interesting in a scientific or theoretical point of view,—the dearness of the acids, and the injury to the cloth, both with regard to strength and being made more combustible by the treatment, put it entirely out of the possibility of practical application. When nitric acid acts both strong and hot upon vegetable or animal fibre, it converts it into oxalic acid. Strong cold nitric acid tinges wool and silk of a durable yellow colour; upon silk it has been applied practically as a dye, but I believe it is

little used now. It must not stop more than a few moments in the acid, or it will be destroyed. What is said of acids is true with respect to acid salts, in proportion as the salts contain free acid, or as they may give it off in a free state under the processes to which they are submitted, upon or in contact with the cloth. Such salts as bi-sulphate of potash, sulphate of copper, muriate of tin, and nitrate of iron, are, under certain circumstances, likely to rot the fibres they are applied to, because they either contain free acid or are so constituted that the acid becomes easily separated from the base, and acts with destructive energy. In all these cases wool resists better than cotton, and many a colour safe and good applied upon wool, will destroy calico if applied to it; silk holds an intermediate position, nearer to cotton than to wool.

Chlorine acts upon fibres, when in a strong state, but it is a question whether it acts as such, or by forming muriatic acid with the hydrogen of a portion of the material acted upon; it colours silk and woollen yellow, which muriatic acid does not, but its action upon cotton fibre is very similar to the action of muriatic acid. It is not likely that under ordinary circumstances it will ever be required to use chlorine in that state of purity where its action becomes destructive. Chlorine, as developed from chloride of lime and sours, acts beneficially upon wool for receiving colours, but whether it is upon the pure fibre of the wool, or only upon the tin prepare, is not clear. The action of chlorine upon cotton turns practically upon the action of bleaching powder upon it. This is known to be destructive in some cases, as when it is exposed to the air in contact with it, or kept hot in strong chemic solutions, &c.; it acts chemically, and according to the observations of some chemists, a kind of combustion goes on, the fibre is oxidised, and carbonic acid gas given off. Under all ordinary circumstances of bleaching, raising colours, clearing, &c., the chloride of lime has no action at all upon the fibre, but only upon foreign substances in it or upon it, or if it has an action, it is too obscure to be perceived.

Action of the Alkalies upon Fibrous Substances.—The alkaline substances with which fibrous matters are likely to be placed in contact in ordinary circumstances are soda, as soda ash or carbonate, and also in the caustic state; potash in the same conditions; ammonia or carbonate of ammonia, as in putrid urine; lime, as in bleaching, both in the state of clear lime water and as milk of lime, containing solid lime diffused through water; also some kinds of soap, which are very alkaline.

Potash and soda, in their natural state of carbonates, before being made caustic with lime, have no particular action under ordinary circumstances upon cotton fibre, that is, whether weak or strong, hot or

cold. American potashes often contain some portion of caustic potash, whose action is more energetic than the carbonate, and may produce more marked effects. Soda and potash in the caustic state do act upon cotton, and differently as they are hot or cold, strong or weak. Weak, cold caustic, say as high as 10° Twaddle, will not act injuriously upon cotton steeped in it for a considerable length of time; if the cotton be repeatedly exposed to the air while it is wet with the caustic it is liable to be affected, but not strikingly so; if the same strength be made hot it will injure the fibre very much, and in no long time make it as rotten as wet paper. What the chemical change is which takes place under these circumstances, if indeed any such change takes place, is not known. Some chemists suppose an oxidation, but that is not satisfactorily demonstrated, and some cases which have occurred under my observation where oxidation could not take place (because there were deoxidising agents in the caustic, as grape sugar), make me doubt if the oxidation has anything to do with it. Some cotton fibre resists longer than others the disintegrating action of caustic solutions, producing results of a very anomalous nature on various kinds of cloth; sometimes pieces are rotted in alkaline solutions, which do not mark more than two degrees on the glass, while other pieces are not affected at four times that strength. Cloth which has been subjected to several treatments, as, in dyeing, to the action of acids, soap, lime, chloride of lime, &c., seems to be easier acted upon than cloth which has not been through so many operations. Very strong caustic has a peculiar effect upon cotton fibre, causing it to contract or shrink up; if a few drops of caustic soda, at 50° Twaddle, be dropped in the centre of a bit of calico, it will be seen that it causes a puckering, owing to the fibres touched by the alkali contracting in length and pulling the others up: this effect remains upon washing, and is not removed if the calico be steeped in sour. This action was known long ago, but no notice taken of it until Mercer, to whom calico printing and dyeing owes several happy discoveries, announced that the action of strong alkalies was to make cotton fabrics stronger than they were before, and to endow them with a superior attraction for most colours. He patented the process, which seemed to promise great results, but unfortunately it has not turned out so valuable or useful as was expected. Upon passing the pieces in caustic soda, at from 40° to 50° Twaddle, they appear to become transparent and gelatinous, at the same time contracting both in width and length. They are not allowed to rest in the caustic more than a few minutes, and then washed off in water, and the last remains of the alkali removed by a weak sour. When dry, the cloth has a rather

different aspect with regard to colour than before treating; it does not reflect so much white light, but has a translucent appearance,—the threads appear rounder, firmer, and closer together. The contraction in breadth upon good printing cloth would be about one-fifteenth, and the same in length, which accounts for the closer texture. Analysis shows that some soda remains, combined with the cotton, however well washed, and this points to a chemical combination between the alkali and the fibre—the souring takes this soda out. Cloth thus treated shows a superior affinity for some colours, especially the indigo blue; it takes as deep a shade of blue in one dip as common cloth takes in six, and, generally speaking, colours look better on this than on untreated cloth. The strength of the fibre is improved, but not more, I believe, than could be explained by the contraction of it. The expense of the soda, a large quantity being required, mainly caused the abandonment of this plan of treatment; and, besides this, the advantages were not of that distinct nature which would justify anything beyond a very small expense in the treatment; and the contraction of the fibre was an objection, for, though it made the cloth look finer and closer, that is an effect which can be more surely and economically produced by the loom.

Lime has no injurious action upon cotton in any moderate quantity, or applied under any ordinary circumstances. Injuries to cotton by lime will be found to exist generally where the cloth has been exposed to the action of the air and lime at the same time in conjunction with heat. It is not known that the air acts chemically in assisting the lime to injure the cloth; I think it only dries up the water, and brings the lime more closely in contact with the fibre. Some degree of heat higher than the natural temperature seems to be necessary to the destructive action of the lime. As a general instruction it may be said that it is injurious to expose pieces in contact with lime to the action of the air. It sometimes happens in bleaching calicoes that the kier is run off, and the pieces left some time before running up with water are taken out. This is a condition very likely to injure the cloth, especially those parts which are in contact with the hot sides of the kier,—for there is lime on the pieces, the air penetrates as the liquor runs off, and the hot iron gives the heat; the vacant spaces, caused by the folds of the pieces, being for the most part filled with steam from the hot liquor still remaining, often saves them when otherwise they would be tender.

Potash and soda, whether carbonated or caustic, act destructively upon both silk and woollen, and must be employed in contact with them only in very weak states, and with much care. Tolerably strong ash dissolves woollen cloth up altogether, and when weak it is apt to injure

the texture and properties of silk and woollen long before it arrives at the disintegrating point. Even lime is injurious in this way. The caustic alkalies make a kind of soap when boiled on wool; the addition of acids throws down a white pulp, and a disagreeable sulphurous smell comes from the mixture, owing to the sulphur, naturally existing in wool, taking the form of gas. Soap of a slightly alkaline nature, and solutions of crystals of soda, rather weak, are the strongest alkaline substances which should be permitted long contact with wool. Ammonia in its strong state has an injurious action upon wool; when mixed with water it is not injurious, if it is not kept too long in contact with it. Fermented or putrid urine, which is used in bleaching wool, is alkaline, owing to the carbonate of ammonia contained in it. This does not appear to exercise any injurious action upon the woollen fibre, while at the same time it acts upon the grease in it. Ammonia is rather hurtful to silk in the strong state, but, moderately diluted, it may be used for any purpose for which it is adapted, without inflicting injury upon it. As a general rule it should be understood that woollen is injured by alkalies, and not by acids; on the contrary, cotton fibre is not affected by weak alkalies, but injured by acids sooner than wool.

Action of Salts upon Fibrous Substances.—The phenomena of the decomposition of metallic salts by fibrous matter, or in presence of fibrous matters, form one of the most interesting and difficult branches of the chemistry of dyeing and calico printing. There is a difference of opinion among chemists as to what power it is by which fibre is enabled to retain certain amounts of metallic substances, some contending for a real chemical attraction on the part of the fibre, others considering that the adhesion is simply of a mechanical nature. This question involves several theoretical considerations, and will be more fitly treated upon afterwards; at present the principal effects produced by the contact of salts with fibre will be considered, without regard to the theoretical views.

A Salt may be Entirely Absorbed or Retained by the Fibre.—This case is only common when the salt is insoluble in water. To be considered as absorbed or combined with the fibre it is necessary that the fibre should retain the salt, or a portion of it, when washed in water. The cases in which a whole salt, in all its parts, is retained upon the fibre are few, not considering at present that the colouring matters form salts. The chrome yellow and orange, being respectively the chromate and subchromate of lead, are salts; Prussian blue is the ferrocyanide of iron, and a salt. These two bodies being insoluble salts, and produced from two soluble salts, are formed as it were in the fibre, and not being

dissolvable in water are retained by it. Other insoluble salts, which can be formed in the same way, have not the same hold upon the fibre, and can be removed by brisk washing and agitation. What the difference of adhesion may be owing to is not well known. Woollen fibre is able to retain some salts in it which are soluble in water, for example, alum; if wool be boiled with a weak alum water it takes up some of it, which cannot be removed by washing, and is said by some chemists to be there in the state of alum, the same as common alum. Cotton can attract to itself some insoluble or slightly soluble salts, and retain them with considerable tenacity, such as the sulphate of lead, newly precipitated, and the chromate of lead in the same condition: when once these have been printed on calico, and left for a short time, they have become fast, and cannot be washed off. But altogether the cases in which complete salts, both acid and base, are retained by the fibre are few, and form only an unimportant series.

Several Salts are Decomposed under the Influence of Fibrous Substances alone.—This case frequently happens with all three kinds of fibre, and is much taken advantage of for mordanting them. Calico, passed through a clear solution of nitrate of iron, decomposes it by taking up some of the oxide to itself. It holds firmly to this, no washing in water will remove it, and it may even be passed in dilute acids without losing its iron; silk does the same. If calico be passed through hot alum liquor, it does not take up any of it that cannot be removed by simply washing. Wool, as just stated, does take up some of it, but not much; for, unless assisted by some other agent, it cannot remove either the alum from the water, or take the aluminous base from the strong sulphuric acid in any useful quantity. Substances are therefore added which will fill up the acidity of the salt caused by the abstraction of the base; when thus assisted, wool can withdraw a considerable amount of the aluminous base from the alum, but in what precise state it exists in the wool is not known. The salts of tin are easily decomposed and portions of them retained on the fibre, by simply passing the fibrous substance through solutions of them. Many other metallic salts are acted upon in the same way, and the fibrous matters are able to take the metal of the salt easier and in greater quantity, as the combinations between the acids and oxides are feebler. Many nice chemical affinities and balancing of attractions are shown by the behaviour of fibrous substances with solutions. The aim to be kept in view in depositing metallic oxides in this manner is generally to render the metallic salt itself unstable, to substitute weak acids for strong acids, and to induce, as far as possible, the formation of that class of oxides which have the smallest force of attrac-

tion for the acid. When a fibrous substance takes up metal from a solution, it may be looked upon as an acid entering into competition with the acid already existing in the salt, for a portion of the metallic oxide combined with it. If its attraction was very superior, it might take all the metal from the acid, but this never occurs; so long as there is acid present it will retain a portion, and the largest portion, of metal. If the excess of acid is kept neutralised by any means, it, of course, is continually putting the fibre into a condition to remove more and more of the oxide, and this is what is practically done when tartar, chalk, and carbonate of soda are added to mordants, and also when acetates are mixed with them. The acid of the acetates is a weak acid comparatively, especially because it is volatile; this volatility only takes place when it is dry and in absence of water, or when only very little water is present; it is, therefore, not much used in mordanting in liquids, but it is of essential use in cases where the cloth is dried with the mordant in it, as in calico printing, and in some cases of dyeing.

Some Salts are Decomposed by the Fibre, with assistance of Chemical Additions.—This, as partly explained in the last section, is the most ordinary method by which salts are sought to be decomposed for practical purposes on cotton, wool, and silk. The chemical additions are usually of such a nature as to weaken the existing affinities between the acid and base, and then the fibre steps in and helps the decomposition, attracting to itself the insoluble, or slightly soluble, substances produced. For example, if clear alum liquor, as strong as it can be made, were thickened and printed upon calico, it might be aged any length of time, but would all wash off in water, leaving no mordant attached to the cloth. But if a certain amount of acetate of potash was to be dissolved in the same alum liquor, and then thickened, printed, and aged, it would be found that a good deal of mordant was attached to the cloth, and that it would dye good colours. The chemical effects of this acetate may be stated as follows, assuming for the sake of facility of illustration, that the cotton fibre has a tendency to attract the aluminous base, and is continually soliciting it from the alum. Alum is a sulphate of alumina, and every particle of alumina being combined with one of the strongest acids known to chemists, the solicitations of the cloth are powerless to overcome the resistance of the sulphuric acid, just as the solicitations of gravity on a weight are overcome by the strength of the string which suspends it. But the addition of the acetate of potash changes the internal structure of the alum; the sulphuric acid goes to the potash in part to form sulphate of potash. It cannot do this without leaving the alumina in part, and as soon as it does so, the cloth acts upon it and seizes it;

the acetic acid, which has been driven out of the acetate of potash by the more powerful sulphuric acid, escapes in vapour, having nothing to detain it; the decomposition proceeds until eventually all the alumina is fixed by the cloth, and there remains only sulphate of potash upon it in a loose state, all the acetic acid having gone away in vapour. Other acetates act in the same manner, and other metallic salts the same as alumina. A number of important decompositions of metallic salts take place in a more direct and less complicated manner than when the acetates are used. These are cases where the salt which is wished to be decomposed is at once placed in contact with substances which have a stronger affinity for its acid than the oxide it contains can exert, when, of course, the acid leaves the one oxide to go to the other, and the oxide which is left without acid remains attached to the fibre. Lime is the oxide most frequently employed, because it is cheap and its affinities are very powerful, but potash and soda act more powerfully still, and their greater or lesser use for this purpose, as compared with lime, depends not so much upon chemical as upon economical considerations. Cases in point here are the chrome green shades, iron buff, manganese brown, and the puce from lead salts. Suppose the chromium salt which has been printed on the calico is the sulphate: when it is passed in lime there is formed sulphate of lime, by all the sulphuric acid going to the lime in preference to remaining with the oxide of chromium; in consequence the oxide of chromium is left to itself, insoluble in water and adhering to the tissue, it withstands washing, which the sulphate would not. I know it is a common error to consider that lime fastens this class of colours, by combining with them in some manner; but it is not so. The lime performs all its office in the raising beck, and when the piece is washed, there is none left on it at all. In the case of acetate of manganese, or acetate of iron, it is acetate of lime which forms in the raising, because it is the acetic acid which was combined with the metallic oxide.

Heat has a great influence in changing the affinities and composition of salts, especially in mixtures of them. It is for the purpose of effecting such changes that steaming is employed upon topical colours, and hot stoves, or baths, on dyed colours. The easy destructibility of all vegetable and animal fibre by heat prevents the development upon it of several mineral colours, which can only be accomplished by high temperatures, such as red lead, vermilion, ultramarine blue, etc.

Wool does not behave, with regard to metallic bodies, in the same way as cotton. Generally speaking, metallic colours are not good upon wool; this seems to be owing to its chemical properties, which show

themselves mostly by deoxidising substances placed on it. It is not possible, for example, to get any good shade of buff on wool from the oxide of iron, neither a good brown from manganese, for either the nature of the wool never permits a full oxidation of these metallic colours, or else it speedily deoxidises and deteriorates them. The same remarks are true concerning silk. In mordanting wool, either with aluminous or tin salts, the use of tartar appears necessary. In a previous section some remarks have been made with regard to the probable uses of tartar in dyeing woollens; here it will be proper to consider what part it acts in combination with mordants. Tartar is the compound of potash with tartaric acid, and tartaric acid belongs to the same class of acid bodies as acetic acid, and with regard to the strong mineral acids has about the same relations, excepting that it is a fixed acid. When tartar is mixed with alum, and in contact with woollen fibre, there seems no good reason to doubt that it acts much in the same manner as acetate of potash would do; that is, part of the sulphuric acid of the alum goes to the potash of the tartar, leaving the alumina in a weaker state of combination, so that the wool can exert its attractive force for this body with less resistance and greater effect; for supposing a tartrate of alumina to be formed by the exchange of acids between the alum and tartar, the tartaric acid, being a so much weaker acid than the sulphuric, could not restrain the alumina from entering into combination with the wool. But it is not probable that a tartrate of alumina is ever actually formed, the decomposition is not pushed so far; only so much tartar is required as will be equivalent to taking away a small portion of the sulphuric acid from the alum, for when alum is robbed of a little of its acid it becomes easily acted upon by substances which have an affinity for the alumina, a compound being produced called cubical alum, or basic alum. (See page 92.) The same explanation may be accepted in the case of tin mordants; the acid being partly killed lets its tin go to the wool with so much the greater ease.

In mordanting cotton with tin, the process that succeeds with wool would give only very indifferent results, principally because its affinity is less powerful, and because, as explained before, it does not stand contact with acids so well as wool. It has to be done, then, in another manner, and the alkaline salt, composed of tin and soda, and called stannate of soda, is employed instead. This salt differs from ordinary tin salts, for it has the tin dissolved by alkali, while *they* have it in solution by reason of strong acids. A different method of fixing is then required, depending upon the difference of chemical constitution. The cloth is impregnated with a solution of the stannate of soda, and then passed

through dilute sulphuric acid. The action is simple,—the soda goes to the acid, and the tin, being set free, combines with the fibre of the cloth. The cotton fibre would have no power of itself to withdraw tin from the stannate, especially in the very alkaline state of the commercial article.

The great majority of salts known to chemists, as well as those which are employed in manufactures, have no action at all upon fibrous substances; this is the case with nearly every neutral saline compound. It is only in the cases of the oxides of aluminum, iron, and tin, that fibres appear to exert a decidedly attractive influence; it is difficult to leave either vegetable or animal fibre in contact with salts of these metals without their taking up and fixing more or less of them. The most powerful affinity is for tin; it is absorbed under circumstances where the other oxides are not, and it retains its hold upon the fibre under influences which readily remove the other metals. There are cases where the combination of the tin with the fibre is so intimate that nothing short of the complete disorganisation of it will enable the tin to be completely separated from it. Further observations connected with these matters will be found under the head of mordants.

Solubility of Fibrous Matters.—The case of disintegration of fibre is common enough under the influence of acids and alkalies, but a case of real solution of it was not known until quite recently, and has occurred in connection with a chemical mixture where this action would never have been suspected from analogy. The oxide of copper is soluble in ammonia, and the solution thus produced may be called the ammoniuret of copper. It can be best prepared by dissolving sulphate of copper, at the rate of one pound per gallon, in cold water, and adding weak caustic soda until all the copper is thrown down; the pale blue sediment should be thrown upon a filter, washed, and drained; it will be soluble in strong ammonia liquor, with production of a magnificent purplish blue colour. This solution should be kept in a bottle or covered vessel, because it is injured by the air. This liquor is the solvent for cotton: it acts also upon silk, but not so strongly; and upon wool, but still less so. There are other solutions of metals in ammonia better adapted for dissolving silk and wool, as those of cobalt and nickel. If a piece of calico be placed in the ammoniuret of copper it is soon acted upon, becomes gelatinous, is brought into a pulpy state, and finally, if not in too large a quantity, is dissolved. If this solution is mixed with acids the cotton is thrown down as a white powder, and, according to the statements of the chemist who discovered this solvent, it

remains of the same chemical composition as before, but all traces of fibre are entirely gone. Before the discovery of this curious fact cotton was considered as insoluble in all liquids. What practical results may flow from the knowledge of this solvent, or what insight it may give us into the nature and chemical bearings of cotton itself, cannot yet be said.

Affinity of Fibrous Substances for Vegetable Substances and Colouring Matters.—All the fibrous substances receive colouring matters under some conditions, which vary for the particular fibre and the special colouring matter. As a general rule it may be laid down that the animal fibres have a stronger attraction for colouring matters than the vegetable fibres; they not only imbibe them more easily and with less preparation, but they hold them more firmly and protect them better from the destructive influences of air and light. There are some colours which cannot be fixed at all upon the vegetable fibrous substances, which give good shades upon wool and silk; picric acid is a notable example. Others fixed upon cotton are weak and unstable, easily destroyed by natural agencies, while the same colouring matter upon wool and silk enjoys a fair degree of permanency—the case of archil is an illustration. There are, on the other hand, some colours which fix better on cotton than on wool—principally the metallic colours—and some which are not good on wool because of its too great affinity for colouring matters, as in the case of madder; the wool does not permit the removal of the brown matters, which deteriorate the madder red. Some vegetable substances, not colouring matters, have a strong affinity in certain cases for fibrous matter—such, for example, as the tannin matter of gall nuts, of sumac, &c. It may be observed that these substances are all what are called astringents, and it is not known what kind of combination they form with the fibre; but it is one of a very intimate nature, and its permanency resembles the combinations which are formed by mineral matters with it. The combination, or, more properly speaking, the adhesion of certain other substances, such as albumens, oils, caseine, &c., is not of a chemical nature. They adhere by virtue of becoming entangled by coagulation with the net work of fibre, or they adhere by their closeness of contact like paint to a wall. It is certainly of no consequence in a practical point of view, how or why a colour or a substance adheres to a cloth, so that it does adhere; but it is well to have an understanding as to what adhesions are due to chemical powers, and what can be attributed to mechanical or physical causes. The more the matter is studied, the more difficult it appears to mark the line of division between these combinations, which appear to

be due to chemical phenomena, and those which are due to mechanical. The result upon my mind has been to make me consider that all these kind of combinations can be equally as well explained one way as the other, and that chemical phenomena are only a subtilised kind of mechanical operations. See further, Chapter 29, on "The direct application of colouring matters."

CHAPTER XX.

COLOURING MATTERS.

WITH a few exceptions all the colouring matters used in dyeing are of vegetable origin. The plants or trees yielding colouring matters are very unequally divided over the surface of the earth. Except a few lichens, the regions bordering on the frigid zone furnish nothing for the use of the dyer. In the temperate climates it requires assiduous cultivation to produce a few of the roots and leaves yielding tinctorial substance. The great source of dyeing materials lies in the tropics, where alone they appear to flourish in a vigorous and natural state. The colouring matter for which a plant is valued may exist throughout its whole structure, but is more usually found concentrated in some one part. Thus in madder, alkanet, and munjeet, it is in the root; in logwood and fustic it is in the heart of the wood; in sumac it is in the small branches and leaves; in safflower it is in the flower; in Persian berries it is in the seeds. The amount of real available colouring matter which is contained in the different organs of the plant, which are used for dyeing purposes, bears generally a very small proportion to the other and useless matters present. For example, in madder root, from ninety to ninety-five per cent of the weight of the root is fibrous matter and soluble principles, which do not contribute to the dyeing, the remaining five or ten per cent being pure colouring matter. The amount of colouring matter rises higher in logwood, berries, and cochineal, while in the cases of indigo and catechu, which are manufactured products, the whole or one hundred per cent may be colouring matter. But as they existed in the plant and tree before extraction, they were present in only very small quantity. For convenience of treatment, the colouring matters will be classified according to the shades of colour they yield, but as some yield two or more shades, according to the mordant

employed, the colour produced by the aluminous mordant will be taken; thus, madder will be called a red colouring matter, though it can produce black, purple, and chocolate colours.

RED COLOURING MATTERS: MADDER — GARANCINE — ALIZARINE — COCHINEal — KERMES — SAFFLOWER — PEACHWOOD — CHICA — MUREXIDE — FUCHSINE, ETC.

The madder plant grows in many parts of the world, and seems to yield a nearly equal product in very various climates and situations. It is not cultivated for commercial purposes in this country, but is largely grown in France and Holland, whence the bulk of that used in England is obtained. Madder roots in the unground state are imported from the Levant and called Turkey roots; small quantities are obtained from other countries in Europe, and some from the East Indies, generally known as Bombay roots. The madders from these places are very similar in chemical and tinctorial characters—their differences do not appear to be of an essential nature. Some are preferred for one style of work and some for another, while some are not so rich in colouring matter as others. The market price is a correct evidence of the goodness of a known kind of madder; the tests of its quality being perfectly practical in their nature, are for existing methods of using this colouring matter unmistakable, and the true commercial value of a madder is soon ascertained. The French madders are in a state of very fine powder, packed tight in large casks, where, owing to a gelatinous or gummy substance which all madder contains, the whole powder is sometimes firmly cemented together, requiring to be cut with a pickaxe; when placed in water the gummy matter immediately dissolves, and the madder falls to powder. The roots which are imported are generally ground by the consumer. I have made many experiments as to the fineness to which madder should be ground, so as to give out all its colour, and working upon Turkey roots, I have found as a general result, that there is no advantage in bringing it to a fine powder; if it passes through a sieve of about twelve wires to the inch, it is fine enough. The French madder, when dry, will pass through a sieve of eighty wires to the inch. That degree of fineness is perhaps necessary to make it a commercially saleable article, but for a manufacturer to grind his own roots so fine, would be a great loss of labour without any corresponding advantage. The reason for this lies in the texture of madder; it is not like a hard wood, enclosing its colouring particles in walls of

insoluble ligneous fibre, which must be torn up by mechanical force, in order to set them at liberty in the dye beck; it is, on the contrary, soft, it contains one half its weight of gum, sugar, salts, and other soluble matters, which the water speedily dissolves, and reduces the remainder into a porous, spongy state, so that water has easy access to the colouring matter. The finer particles which all ground madder contains, if separated by a sieve from the coarse parts, will be found to be no better for dyeing, but frequently rather worse, because they generally contain the sand, stones, and dirt, which grind to dust sooner than the tough fibre of the root.

It is a general opinion that madder, when well kept, improves for some years after it has been gathered. A kind of slow fermentation appears to go on, the madder swells, often bulging out the casks, and even bursting them. I consider that the question of the improvement of madder by age is not a general one, it is confined to peculiar qualities; the contradictory results of many experiments, and conflicting statements of those who have compared fresh and old madders, can only be explained or reconciled by this supposition. With regard to Turkey roots, I feel certain they are old enough when they arrive in England for all useful purposes. Madder, under ordinary circumstances, is not deteriorated by age, nor even sensibly altered, if it has been kept dry and out of strong light. I have had an opportunity of trying madder forty years old, which was very little different in its behaviour from fresh madder of the same kind. Its solution in the beck was blacker and of a different taste to new madder, but the colours it yielded were as good in every respect. It has been proposed to moisten madder with water, or expose it to a damp atmosphere to absorb moisture, with a view of extracting its colouring matter more quickly or in greater quantity. This method, though found useful with regard to many dyewoods, is no good in the case of madder. I have tried it under many different circumstances. If madder be exposed to a thoroughly moist atmosphere it will absorb about twenty per cent more water than it usually contains; this will make it feel damp, it will adhere together when pressed, and its colour is heightened. If degged with water its gummy character makes it adhere in lumps, and it cannot be turned over and exposed to the air in the same way that logwood or fustic can. Either of these treatments leaves the madder about the same for dyeing; there is no perceptible improvement in it.

Action of Solvents upon Madder.—If ground madder is stirred up with a large quantity of cold water, and strained off clear, without standing more than an hour, a good deal of the colouring matter will be removed by the water. It is not possible in this manner to extract all

the colouring matter from madder, and the portion extracted is mixed up with so much sugary and gummy matters as to be of no use as an extract of colouring matter. If the madder be left to stand for twenty-four hours before straining, it will be found to have assumed a gelatinous state, more or less apparent according to the quantity of water used, and if the liquor be pressed out it will be found not to contain any appreciable quantity of the colouring matter of the root. This is a very curious property of the colouring matter of madder: it will dissolve if it does not stand; if it stands it becomes insoluble, and only the soluble and useless part of the root is washed away. In this manner madder is often treated. It loses nearly one half its weight; when dry has a peculiar smell, somewhat resembling sour milk; it is lighter coloured than before the treatment, and does not injure the whites so much in dyeing. It is called in trade "Fleur de garance," or, in English, "Flowers of madder." It is suitable for some styles of work, but it presents no advantage on the score of economy; it goes about twice as far as madder, and is about twice as dear; not tinging the whites so much as madder, it saves soap, and can even be cleared without soap, but in such case the colours are dull.

Hot water, if poured upon madder and strained off, dissolves some colouring matter, but less than cold water; if left to stand until cold, it acts nearly the same as cold water. Both hot and cold water, when not left standing on madder, injure the undissolved residue to an extent which seems disproportioned to the amount of colouring matter to be found dissolved by them.

The other liquids which are generally used as solvents for colouring matters do not make any satisfactory extraction of this root. The colouring principle of madder is an anomaly in its behaviour to different substances. In some respects one of the strongest of colours, it is at other times injured or destroyed by the slightest chemical action. It appears to be at the same time soluble and insoluble in water. How are these conflicting phenomena to be explained? Either by supposing that there is more than one colouring matter in the root, or that, if it is a simple principle which yields all the shades, it must be capable of assuming different forms and properties, passing from one condition to another, as from a soluble to an insoluble one, and so on. Indeed it seems probable that madder does not contain a really isolable colouring matter, but it contains something, or perhaps several things, which, under the influence of water, air, warmth, etc., become colours. By several complicated chemical processes a substance can be obtained from madder, in small quantity, which is crystallised in beautiful orange-red

coloured needles ; it is named *alizarine*, and is the reputed pure colouring principle of madder. There can be no doubt that it is so in a most important manner, since all the colours which madder gives can be obtained from these crystals, by simply dyeing mordanted cloth in them. But it may not be the only colouring principle in the root, or it may not be in the root at all, but produced by the chemical operations performed upon it. That is of no practical consequence ; it is either in the root, or something else which forms it is there. It does not appear necessary to look for other colouring matters while this one is capable of yielding all the shades which madder itself gives. There may be, indeed, a separate principle for the red colour, and one for the purple, and, if so, also one for the black and chocolate ; but it is apparent, if this be the case, that they are respectively convertible, under the influence of mordants, one into the other ; and for all practical comprehension of the properties of madder, the assumption that there is only one colouring principle, and that one *alizarine*, may be held as true. The peculiar behaviour of water upon madder may be considered as attributable to the *alizarine* existing partly formed and partly unformed ; the completely formed portion not being sensibly acted upon by cold water, and very little by hot, while the unformed *alizarine* is dissoluble by water, but has a constant tendency to pass into its complete state of *alizarine*, in which it is not dissolved by water. The jellifying of the madder has probably no necessary connection with this alteration of the colouring matter, for the gelatinous substance can be separated, and is found to possess no dyeing properties at all. What the water takes away is vegetable extractive matter, partly of a gummy, partly of a saccharine nature, and some earthy matters which are soluble in water ; what it leaves behind is woody fibre, earthy matter, this peculiar jelly-like matter called by the chemists *pectine* and *pectic acid*, and also the *alizarine*.

A question of the highest importance is yet pending with regard to the colouring matter of madder ; to extract it in a pure state from the other matters that are along with it in the root, or if not in a pure state, yet sufficiently strong and pure to resemble other extracts, as log-wood liquor, sapan liquor, &c. If this could be accomplished, it seems probable that it would be more economical to use it as a steam colour than to dye with ; it is likely it would yield better shades and more regular results, and be in many cases extremely preferable to the mixture of a small amount of pure colouring matter and large amount of useless encumbering matter which constitutes madder. The Industrial Society of Mulhouse has at various times offered large premiums and honours to any one who should resolve this question in a satisfactory

manner, having regard to commercial requirements. These inducements and the certainty of otherwise making large profits, have led some of the ablest men in France and England to turn their attention to this topic, but without the slightest success so far. Nothing, perhaps, could so well illustrate the immense difficulty of dealing with this matter than the failure of so many attempts to accomplish something, so well defined as a solution of the colouring matter of this root. Solutions and extracts have been made, but they did not fulfil the required conditions: they were either too impure and contaminated with foreign matters, or else were too expensive on account of the use of spirits of wine, or such solvents, in extracting the colour. Some of these extracts have been employed on a small scale, and pieces done with them which, if not perfect, at any rate seemed to indicate the strong probability of success awaiting continued efforts in the same direction. To judge by the numerous patents taken out in this country and in France with reference to this subject, one would be led to conclude that not only was the matter not difficult to accomplish, but that actually a great number of persons had succeeded in accomplishing it. There could not be a greater mistake; either the enrolled specifications of those patents are fraudulently deceptive in concealing the real method of accomplishing the end, or else the patentees are most lamentably ignorant of what has been done and attempted to be done in the same direction. Processes are patented which are perfectly impossible, and one might imagine that the parties did not actually know what madder was, or had never worked upon it for an hour in their lives. Much information upon the behaviour of madder, under various circumstances and with various chemical re-agents, has been acquired, but nothing of any practical utility has yet resulted from experiments to concentrate it by extraction. It is a subject yet inviting to research, and seems to promise great things to the discoverer. A necessary condition in preparing an extract of madder is, that it must not, at least, give inferior results to those at present obtainable by dyeing. No facilities of application would compensate for inferior results, and no extract can hope to meet with extended employment, which does not enable the printer or dyer to produce as good or better results than he can now obtain. There is a sufficient margin in the amount of colouring matter which is never obtained from the roots to make an effective extraction pay for its expenses, if these are not very heavy by the use of solvents, which are dear in themselves, or get lost in the process of extraction.

Madder does not give up all its colouring matter to water, however long it may be boiled with it, even in the presence of mordants, which

remove it from solution as fast as it is dissolved. This may not be true when very large quantities of water are used for comparatively small amounts of madder, but in all practical dyeing operations it is the case. The spent madder contains nearly as much colouring matter as has been extracted from it, but it must be in some different form, or else it would come out upon treating with fresh water. The only way in which it can be obtained is by treating the spent madder with acids; the acids liberate the colouring matter, and when they are washed away again, the spent madder is able to dye up almost as before. (See *Garancine*.)

The colouring matter of madder is dissolved by alcohol in larger quantity than by water, but it does not extract it from the root in any degree of purity, but mixed with several other substances. It is soluble also in acids, when heated, and generally falls out again when cold. Boiling alum water dissolves it in comparatively large quantity, and lets it settle out upon cooling as a yellow-coloured sediment. The caustic alkalies, ammonia, potash, and soda, dissolve it to a large extent, but not in its integrity. They cause it to undergo some change, which either injures or destroys it, and this is more especially the case when they are left in contact for any length of time. Even the milder forms of alkali, as the carbonates, bi-carbonates, and the borates, injure it very much indeed if left in contact with it.

Action of Heat upon Madder.—Madder is so complex a substance that the influence of any chemical agent upon it resolves itself into the action of the agent upon several matters mixed together, and produces results which defy all attempts to say where the principal action has been exerted, and how far secondary actions have influenced the final result. So it is with heat. Madder is injured by heating; if steamed it is much deteriorated, and more by low pressure than by high pressure steam. Dry heat above the boiling point of water does not injure it nearly so much as moist heat. Madder may be exposed to a temperature of 300° F. without being much injured, but if the temperature be pushed a little higher it begins to be seriously injured, and at a roasting point it is destroyed. The pure alizarine can be sublimed by heat in crystals; it is not destroyed by it, but as it exists in madder, mixed with many other substances, it does not sublime but is destroyed. M. Camille Koechlin, and others more recently, have proposed a plan for extracting the colouring matter from madder by heat and currents of gases, but it could not be practically applied. Messrs. Pincoffs and Schunck have patented a process for submitting washed madder to the action of high pressure steam in the production of a species of garancine, sold under the name of alizarine. If an acid mixture of madder

and sulphuric acid be gently dried, and then exposed on an iron plate to a heat about sufficient to brown flour, there will be formed in a little time on the surface, a number of small crystals of a brilliant orange red colour—these are alizarine, pure so far as they can be obtained, without being soiled with the residue to which they are attached. Much alizarine is destroyed compared with what is obtained by this method; but modifications of this plan might be devised by which the colouring matter could be sublimed away from the worthless residue. (See madder purple and dyeing, Chap. xxxiv.)

Action of Acids upon Madder: Garancine, and Garanceux.—This substance is a product of the action of acids upon madder. Its name is derived from *garance*, the French for madder. It is made from madder by mixing it with sulphuric acid, diluted with water, and then either boiling the mixture or subjecting it to the action of a current of steam, so as to raise it to the heat of boiling water; afterwards, the acid is all removed by washing with cold water, the insoluble powder drained, pressed, dried, and sieved, and usually mixed in sieving with a minute portion of bi-carbonate of soda, to neutralise some traces of acid which the water fails to remove. The product which is made from spent madder is distinguished by the name of *garanceux*, in French, and as there is no English word equivalent or of the same meaning, that term will be used also in this work; the term *spent garancine*, in use in some places, is liable to give wrong ideas and to create mistakes. Garancine and garanceux are not identical in their properties, though having many points of resemblance. The first is seldom made upon print works, and the latter is nearly always made where much madder is used. They do not give exactly the same shades with mordants; for example, a good lilac cannot be obtained from garanceux, but it can be used as well as garancine in dyeing the style of work generally known as garancine work, viz., chocolates, reds, blacks, and catechu colours. For this purpose it is quite as well adapted as the strongest garancine, if it be well made and carefully washed from the acid. To understand the production of either garancine or garanceux and their properties, as compared with one another and with madder, it is necessary to study to some extent the phenomena which attend the action of acids upon madder.

It is known that the addition of any appreciable amount of an acid in madder dyeing is decidedly opposed to the obtaining of good colours; but this is owing as much to the acid acting upon the mordants as upon the madder. It is known also that the colouring matter of madder is in some cases most easily injured, and even destroyed, as by contact with the alkalies and air, with metallic salts, etc. But it was not known

until comparatively recently how well this colouring matter could withstand the action of strong acids. Strong sulphuric acid is well known to be the most corrosive of acids,—destroying organic textures, blackening and disorganising wood, cotton, sugar, and all similar substances: it could scarcely have been expected, therefore, that madder could be mixed with it without being destroyed. But a French chemist demonstrated that not only was the valuable part of madder not destroyed by mixing with vitriol, but that its power of dyeing was somewhat increased by the treatment. The effect of sulphuric acid was found to be the same on the woody part of madder as upon any other kind of wood; the same upon the gummy and saccharine parts as upon gum and sugar in other circumstances,—that is, to destroy them, to change them into charcoal and water; but the essential principle of the madder was found to be less liable to decomposition than its accompanying organic matters,—it remained almost or entirely unacted upon while they were reduced to their elements. When the excess of acid was washed from the charred and blackened mass, it was found that the powder left, which was black like charcoal, could dye up as well as the original madder from which it was made, with some advantages in the purity of the white and clearness of the colours, and some disadvantages with regard to their stability, which was less than in madder. This was the first origin of garancine making, and it was immediately put upon a commercial footing, but for many years made little progress. It was sold as a substitute for madder; of course it failed, and having done some damage, it was looked upon with distrust, until, by degrees, a style was created for it; it fell into its proper place as a dyeing material, and is now very extensively used. The fact that the spent madder, which was formerly run off into the rivers as a waste product, could be converted into a valuable dyeing material was a separate and subsequent discovery, and had few difficulties to encounter when once the idea was entertained and tried. The process was patented in this country, but, upon trial in the law courts for an infringement, it was upset, as not being novel, on the ground of a previous publication in a French work known in England. Since this trial most printing concerns which make use of madder, work it up when spent into garanceux, and thus use it over again.

The blackening of the whole madder, when it is treated with strong sulphuric acid, is due to a simple carbonisation of some or most of the elements of the root; but, to accomplish this the acid must be very strong and unmixed with water: dilute acid does not carbonise vegetable matter. The blackening of madder, when made into garancine by the ordinary methods of a mixture of acid and water, is due to

another cause. There is a peculiar matter in madder, which is called *chlorogenine*, the name meaning a substance which can become green; it is not green itself, but it changes to green by the action of several re-agents, and especially by the action of acids. The intensely dark colour which some samples of garancine have in the damp state is due to the dark green substance thus produced. It looks black, because it is wet and of a dull absorbent colour; the true shade can only be seen by transmitted light. If a solution of madder, filtered clear, be placed in a deep glass, and strong sulphuric acid poured on it, without mixing, this latter will sink to the bottom; but at the line of junction of the two liquids a green colour will be perceptible, which grows in extent and depth, becoming nearly black. If the liquor which comes from steeped madder be boiled in a glass flask with acid it changes colour, and this dark green substance settles down as a powder: it is so dark that it is only when it has been washed and dried that it is plainly seen to be green and not black. In the state in which it exists in the madder root it is soluble in water; but when it has been changed by hot acids it is insoluble, settles down upon the woody fibre, and remains with it. The reason why garancine made from washed madder, and garanceux also, are not dark coloured, is because their chlorogenine has been washed away: and the reason why some kinds of garancine are darker coloured than others is because the original madder contained more chlorogenine. The quality of a madder does not, as far as I am aware, bear any relation to the amount of chlorogenine in it, and, therefore, the quality of a garancine cannot be correctly judged of by its shade of colour. The formation of this dark green substance goes on step by step with the action of the acid in making garancine, but not apparently connected with it; it serves as a test to show the completeness of the action of the acid, for a change of the chlorogenine does not take place unless the garancine be made; but it is possible to make the garancine without using so much acid, or employing a temperature high enough to convert this principle into the green state.

The quantity of acid necessary to convert a given quality of madder into garancine is theoretically and actually very much less than is employed in practice; on a small scale, if the mixed madder taste sour it is enough, but a large excess is usually employed, principally on account of the necessities of working and degging large quantities of madder. The saving in acid and time of washing would, I believe, justify some mechanical appliances to ensure the thorough admixture of the smallest quantity of acid which is found effective. To diminish the acid, however, with the chance of its being deficient, would be to run risks which

the cheapness of vitriol does not justify; but with care I believe one-fourth of the acid commonly employed will suffice for all purposes. When boiling is used, more acid is required than in steaming, or if not required (which is questionable) is always used. The mixed madder and acid are boiled, or exposed to a current of steam, which, if properly regulated, soon raises the heat to the boiling point of water. The heat is maintained for two or three hours, or longer, the time being regulated by the quantity of madder operated upon and its quality, but generally depending upon considerations of convenience. For small quantities it appears that a five minutes' boiling is as good as an hour, but large masses take much time to get thoroughly heated, and the risk in diminishing the period of heating would be that some parts would not be raised to the boiling point. I made a series of experiments upon making garancine at low temperatures, and have found that madder can be changed, at a temperature not exceeding 160° Fahr., to garancine of the best quality, and with trifling quantities of acid. In using sulphuric acid, muriatic acid, and nitric acid, I have obtained results not distinguishable from each other. Other things being equal, muriatic acid gives the darkest coloured product, and nitric acid the least coloured. In the use of nitric acid there is not a very wide margin between the strength at which it acts, in the same manner as sulphuric acid or muriatic acid, and the strength at which its oxidising properties come into play, and totally destroy all the colouring matter. If about half an ounce of good commercial nitric acid be mixed with 20oz. water, and 2oz. madder be mixed up with it, and the whole gradually heated up in a water bath, with regular stirring, the madder looks unacted upon at first, but when the temperature approaches 150° it undergoes a remarkable change,—it becomes of a brownish colour, and contracts into a very much less space than it previously occupied. If the temperature be pushed a little higher, there is formation of the green substance spoken of, which floats in the liquor, and which, if not poured off, will settle upon the madder and adhere to it. If the heat be withdrawn, the mixture cooled, washed until all the acid is removed, and dried, it will be found that the madder has lost more than one-half its weight, and the product is found to dye up like good garancine. The same effects are produced by using sulphuric and muriatic acids. These experiments are interesting, as showing at what temperature the conversion into garancine takes place. By using a little more acid in the case of muriatic acid, a product can be obtained which is perfectly black when moist, and of a dull dark green when dried. It is, therefore, apparent that garancine can be produced without the dark coloured

body which mostly accompanies it when made from unwashed madder. Garancine differs from madder in its constitution, by the deprivation of some principles and the acquisition of some others. Madder in being treated by acids is deprived of all its salts, and so many of the earthy matters in it which form salts soluble in water; it loses all its saccharine matter and the gummy extractive principles. When garancine is made, it consists of, first and principally, the woody fibrous part of the root; secondly, mineral matter which could not be dissolved by the acids; thirdly, the gelatinous matter called pectic acid, which is not dissolved by acids or water; and lastly, the real colouring matter. It is possible that one or two, or even several, other bodies may be present, but not of necessity. The madder in being thus treated loses from one-half to two-thirds of its weight, and as the same amount of colouring matter is present in the smaller weight as existed in the larger, garancine is much stronger than madder, weight for weight. But this loss of weight is not constant; some kinds of madder contain more of the solid, woody fibre, and less of the soft, soluble principles than others do. In such cases the loss is less, and the garancine being encumbered with useless woody matter is not so strong. The kind of madder called *munjeet* is one that contains a very small portion of soluble matters; it scarcely loses weight in making into garancine, and not containing any of the chlorogenine, does not change colour in any notable degree. It produces a very weak garancine, and is employed to mix with others to reduce their strength, or to increase their weight. What the real and essential action of the acids is in producing garancine is not known. It has been imagined that they acted by breaking up the woody fibre, tearing it asunder, as it were, and letting the water get access to the colouring particles previously enclosed, and so transferring them to the dyeing bath. But the weakness of the acids which can be successfully employed, throws doubt upon this explanation. It was supposed again that the colouring matter was in a state of combination with some earthy base, as lime and magnesia; that it could not dye while so combined; and that the acids liberated it by themselves, taking the lime and magnesia. But this is not supported by any appeal to facts or experiments which bear directly upon the question; it may be the explanation, but it is not proved. It seems probable that some chemical affinities of a more refined and subtle nature are brought into play; it is likely that the acid employed forms a combination with the colouring matter, which is itself easily decomposed, even by water. It would not be in accordance with analogy to suppose any formation or creation of colouring matter, but simply to suppose that a portion of the colouring matter is present in some form

or other in which water cannot act upon it; but acids make it susceptible to the influence of water, by what agency is not known.

There are some ascertained facts of the action of acids upon the colouring matter of madder which, though they have no practical bearing, are full of suggestion. It is very well known that garancine is not the same, as a dyeing material, as madder. Its colours are not so fast, either in soaping, clearing, or exposure to the air. The acid has evidently injured the colouring matter in setting it free; it is no longer what it was in the untouched root. Chemistry cannot, unfortunately, give any reason or explanation of this; as a fact it even stands in opposition or exception to other known cases of the action of acids upon the colouring matter of this root. For example, if a piece of Turkey red cloth or dark purple which has been dyed with madder be treated with pretty strong sulphuric acid, the acid will take up all the mordant and leave the colouring matter loosely attached to the cloth; the acid can be removed by washing and then the colour extracted by spirits of wine. This colouring matter may have been subjected to the contact of acid quite as strong as is used in making garancine, and for as great a length of time, but it is not injured like the colour in garancine,—it can still dye up fast reds, pinks, and purples upon mordanted cloth; colours which are not injured but improved by soaping and clearing. Why should acids act so differently in one case to another? It can easily be understood how great an advantage it would be to have garancine give as fast colours as madder; this may be accomplished when we have a more accurate knowledge of the action of acids upon madder.

Garanceux.—The manufacture of garanceux from spent madder is essentially the same as that of garancine, and the same general explanations apply to one equally as to the other. Allusion has been made to garanceux not possessing precisely the same properties as garancine. The difference is not of a radical nature, and may be explained satisfactorily by the different amount of colouring matter present in it in proportion to the amount of woody fibre and mineral matter, both of which are to a certain extent obstructives to the free solution of the colouring matter, and may produce those effects which distinguish it from garancine. The method of making garanceux is simple and well understood, and requires nothing but care and attention to obtain regular results. The spent madder from the dye becks and wince pits is collected in a sufficiently large pit and allowed to settle, usually with the addition of a little weak vitriol, which both stops any inclination to fermentation and throws down a fine powder, which otherwise floats in the liquor. The wet mass should be well pressed, until it does not contain more than

two-thirds of its weight in water, and then broken up and mixed with the acid. About a dozen pounds of brown vitriol to the hundredweight is a good proportion; it should be mixed with about three gallons of water previously to degging the spent madder with it. It is an essential point that the acid touch all the particles of madder, and, therefore, such a system of turning over, sieving, etc., as will ensure a perfect mixture of the acid must be strictly attended to. It is good to leave the degged madder for some days before steaming; many weeks or months of storing does it no harm, and allows the acid to thoroughly penetrate it. The steaming must be watched to see that all the madder gets a fair proportion of steam; if the spent madder be too moist it sets in the steaming cistern, and forms chinks through which the steam blows without permeating the whole mass. It should be so moist as to give water upon pressure between the fingers, but not wet enough to stick together when pressed in the hand. The washing is important, and demands the greatest attention. On account of its loose texture, garanceux washes much faster and easier than garancine; the waters can be run off more quickly, so that two working days are enough to wash it in. The washing is known to be accomplished by the liquor not tasting acid, and by the springing out of a fine slimy powder, which never appears till the washing is almost completed. It is not to be recommended that any alkali should be used to neutralise the remainder of the acid as an usual thing, but it is sometimes done, and then crystals of soda, or milk of lime, may be added in proper quantity. The garanceux keeps better when left a little acid, especially if it is to be kept in a moist state, as will be usually the case in printworks; it can be neutralised in the dyebeck with safety. When the washing is complete it should be pressed again. It might be used in a simply drained state, but it is better to have it regularly pressed, so as to know how much is being used, as well as for facility of storing. Well pressed garanceux contains between a third and a fourth of its weight of dry matter, the remainder being water. The strength of garanceux, in proportion to garancine of the first quality, will vary according to the nature of the madder, and to the proportion in which it has been spent in the first dyeing. Garanceux from mixed Turkey and French madder is equal, as it comes from the press, to from one-sixth to one-ninth of its weight of real good garancine, or when dried it is equal to about one-third. If the madder has been well managed in the dyehouse, making it go as far as possible, and that is evidently the interest of the dyer, it will take nine parts of the pressed garanceux from it to be equal to one part of best garancine, and less as it has been used in excess

of the requirements of the dyeing to begin with. It is a point of the utmost importance to see that the garanceux is properly neutralised, either in the dyebeck or before it goes in; an error on either side, that is, an insufficient or an excessive quantity of the alkaline matter, is equally injurious. I have seen excellent garanceux condemned as worthless, and even sentenced to be thrown away, because too little carbonate of soda was used with it. The most useful matter to neutralise garanceux in the becks is the bi-carbonate of soda; it is very regular in its composition, and of a mild nature; no fixed proportion can be prescribed, because the acidity is various; the highest amount that should be required is about one pound to seventy of the garanceux; if the acidity passes this, good results will not be obtained, it should be washed over again. The lowest amount will be about one pound to a hundred and fifty pounds of garanceux, taking this last in the wet state, and containing about one-third of dry matter and two-thirds of water. The injurious effects of too much soda are perhaps even more marked than a slight deficiency; the colours are dull and cloudy, without brilliancy or solidity. A deficient quantity of soda is shown by a redness of the chocolates, poorness in the blacks, and the general bareness and poverty of the whole of the colours.

The colours which garancine and garanceux give to mordanted cloth are the same as those from madder, with the modifications alluded to previously; the whites are purer, on account of the absence of the soluble matters which stain them in madder dyeing. They will not stand a severe soaping, and cannot be brought to the same degree of brightness as madder colours. These products are not much employed in dyeing by themselves, but generally in combination with some of the cheaper dyewoods, as peachwood, sumac, and bark. Garancine dyeing cannot be understood until the action and nature of these woods are ascertained, since the simple garancine colours are modified and changed in a remarkable manner by the colours produced by these woods. Garancine is not simply a concentrated madder, to perform in less bulk what madder does or can do in larger bulk; it can produce colours which cannot be obtained from madder. The existing garancine styles could never have been produced with madder, however much was to be employed. It is known that a large quantity of madder must be used to get a chocolate, so much so that chocolates are nearly excluded from madder styles, and the best chocolate that can be obtained is of a chestnut colour, and not that deep brown shade which is required in the market. The colouring matter of madder is surrounded with so much foreign substance as to hinder its filling the strongest mordants, and producing

the heaviest shades, which the pure colouring matter can do. Garancine, being free from all these soluble matters, has a free power of combination to the utmost extent of its affinity and saturating power, and can produce those deep chocolates which no amount of madder would yield. It has the valuable property also of working well with other colouring matters, and admitting them to share in producing its effects; this madder does not do in the same manner,—it is itself too powerful, and requires such energetic treatments to restore the whites to a good shade that the weaker dyewoods, which may be used in combination with it, suffer to a great degree in themselves, and tend to deteriorate, to what seems a disproportionate extent, the shades which owe their chief part to madder. (See further, chocolate from garancine, Chap. xxxiv.)

Commercial Alizarine.—Messrs. Pincoffs and Schunck have patented the method of obtaining a product to which they have given this name. It is obtained by washing madder, and submitting it in a peculiar manner to the action of high pressure steam. The chemical action which takes place remains unknown. The patentees ascribe the improved result to the destruction of some yellow or fawn coloured principles present in ordinary washed madder. The madder loses weight during the process. It is the most concentrated form of madder at present known, the best quality being four times as powerful as ordinary madder. It yields good purples and lilacs even without soaping, but better when a slight soaping is applied. Upon good bleached cloth the whites are kept very clear, so that soaping is not really necessary. The advantages of the commercial alizarine, for the production of madder lilacs, resides in the power which the dyer has of obtaining colours of a different degree of saturation to meet the requirements of the market, a point nearly impossible to hit with untreated madder, on account of the preponderance of foreign matters in it. It works very well with other dyewoods and colours. Its deficiency is in not giving a good black with the ordinary proportion of material. Some houses, which employ this product to the exclusion of madder, use a topical black made with logwood, but exposure to air and light cannot fail to show that this is an inferior substitution: garancine is also mixed with it, to obtain a better black. It does not yield good reds or pinks, nor does it present any conspicuous economy in first cost over madder. It deserves attention as being the purest preparation of madder yet produced as a commercial article.

Colouring matters similar to Madder.—Besides the various qualities of madder received from different parts of the world, and possessing general characters of resemblance, although not identical, there are

dyeing matters which come from plants of a similar nature, and possess some of the characters of madder, while they are deficient in others. Several of these are known to be in use in Hindostan, and two or three of them have been imported in rather large quantities into this country. Perhaps the chief of them is the substance known as munjeet. If looked upon as a species of madder, it must be considered a very inferior one, producing the same colours but requiring much larger quantities, and not giving them so bright or so fast. The soluble parts of madder are nearly absent in munjeet. It is a dry, dusty, reedy substance, very different in general appearance, taste, and character to madder. It has been used in Lancashire by some printers, and I suppose that it may be assumed it was found as cheap as madder although much poorer in colouring matter. It seems to answer best when made into a kind of garancine; on account of its woody nature it does not lose much weight in this process, for while six hundredweight of French madder only gives about seven hundredweight of pressed garancine, the same weight of munjeet gives about nine hundredweight. A French writer, who resided some time in India, M. Gonfreville, states that the dyers there produce very fine reds from some roots not known in Europe, but all belonging to the same botanical class as madder, and MM. Persoz and E. Schwartz declare them all to contain colouring principles identical with the colouring principles of European madder, and that with using proper precautions in the dyeing they can be made to yield good colours. Among others of this class of plants, roots, or products, occur the names of *nona*, *chayaver*, *owonkoudou*, and *hachrout*. Some of these are probably synonymes and there may not be that number of separate red dyeing materials of the madder kind which would appear from the list of names. None of them seem to be so good as our own madders; but the native Hindoos can produce dyes from them which are declared superior in stability and brilliancy to those produced in Europe. But their processes are long, tedious, and expensive, and inapplicable to general calico printing and dyeing.

Analyses and testing of Madder.—All investigators admit the production of a crystalline substance from madder, which can yield all the colours for which it is employed; this substance is called alizarine; after that it will be necessary to distinguish the authorities, for here all agreement ceases. It is not demonstrable that even alizarine exists ready formed in the madder root, but it is quite certain it can be produced from it. *Higgins* believes that he has proved that there is an actual formation of colouring matter in the dye beck. *Schunck* considers

he has isolated the colorable principle. *Runge* asserts that there are five colouring principles in madder, which are purple, red, orange, yellow, and brown. *Schunck* and others have demonstrated the existence of a green colorable principle, chlorogenine, which, say, is composed of blue and yellow, and we have all the primary and nearly all the secondary colours in one common dyewood. *Kuhlmann* in 1823 found the following substances in French madder :—

1. A brown colouring matter.
2. A red colouring matter.
3. Ligneous matter.
4. A vegetable acid.
5. A mucilaginous substance.
6. A vegeto-animal substance.
7. Gum.
8. Sugar.
9. A bitter principle.
10. An odorous resin.
11. Saline and earthy matters.

This shows the complex nature of the substance to be examined, and gives an idea of the difficulties of getting at the pure principles. I give two quantitative analyses of madder, one by *Bucholz* the other by *John*. They give very little information, but they are the most recent whole analyses published, and may serve to show the way in which this root has been analysed, and the very curious results which have been obtained. The analysis of *Bucholz* bears internal evidence of incorrectness, and that of *John*, though not so bad as the former, is hardly credible in some of its statements. They are taken from *Persoz*, vol. 1, pp. 483-4.

Bucholz found in air dried madder—

Red extractive matter	39.0
Brownish red extractive matter	1.9
Other extractive matter	0.6
Red resinous substance.....	1.2
Brown red gummy matter	9.0
Ligneous matter	22.5
Matters soluble in potash.....	4.6
Organic salts of lime	1.8
Water	12.0
Loss	7.4
	100.0

John found—

A waxy matter	1.0
Red resinous matter	3.0
Extractive red matter	20.0
Oxidised extractive matter	5.0
Brownish gum	8.0
Ligneous matter	43.5
Acetates of potash and lime	8.0
Phosphate and sulphate of potash	2.0
Phosphate of lime and magnesia	7.5
Silicic acid	1.5
Oxide of iron	0.5
	100.0

M. Schlumberger estimated the amount of colouring matter in good qualities of madder at about four per cent; inferior qualities only yielded him from two to two and a half per cent. I have found good qualities of Turkey madder to contain about sixty per cent of extractive matters, which term includes everything removable by water and dilute alkalis; the woody fibre was therefore about forty per cent. I never could pretend to say either by direct or indirect means how much real available colouring matter there was in a given quantity of madder. French madder, upon an average, contains also about forty per cent of ligneous matter; the 22.5 of Bucholz' analysis is inexplicable. The amount of mineral matter in madder is tolerably constant at about ten per cent; that is, for ground madder which contains the attached mineral matters of the roots besides the contained mineral salts. Madder root cleansed from all adhering soil and sand will give from six to eight per cent of residue upon calcination.

There is no method known by which the value of a sample of madder can be determined in a direct manner from the amount of colouring matter which it contains. The only reliable test is that of dyeing either pieces or fents with the sample in question. A quantity of madder as small as fifty grains will suffice for a laboratory experiment, from which an experienced manipulator can obtain tolerably reliable results. But it requires very great care in placing all the samples under examination in perfectly equal circumstances; the precautions can only be learned by experience.

Madder is said to be adulterated with mineral matters and valueless vegetable substances. As madder admits of no additions of this kind without an immediate injury to its dyeing properties, the dyeing test will suffice to point out the presence of such foreign matter. Various qualities of madder may be mixed together, or even dried spent madder

may be ground up with the roots. These falsifications will all show in the dyebeck. The admixture of other dyewoods with madder for adulterating purposes would for the most part destroy their object, by so injuring the madder as to render it quite unfit for its usual applications. The same is true of garancine; although very few articles are more subject to falsification, it is entirely in the addition of neutral and inert matters which increase the weight. That such an adulteration should be possible for lengthened periods can only be owing to gross ignorance on the side of the purchaser, or a guilty collusion on the part of his servants.

With regard to the scientific investigation of madder I shall confine myself to the published accounts of Mr. Schunck, who may be considered the best authority upon all that concerns the chemical principles of this root. He considers alizarine to be actually contained in madder, since it can be obtained from it without having recourse to sublimation. Its chemical formula is either $C_{14}H_5O_4$ or $C_{28}H_{10}O_8$; in the hydrated state it contains six equivalents of water. When acted upon by nitric acid it gives a peculiar acid, which was at first announced as a new acid, but afterwards proved to be identical with the phthalic acid which Laurent had obtained by the oxidation of chloro-naphthalic acid by nitric acid. Because nitric acid acting upon two separate substances has given rise to the same acid, Strecker and other chemists have been led to believe a similarity in composition of the original bodies; nothing, however, proves this, and the hopes which have been raised of producing alizarine from any of the compounds of naphthaline seem delusive.

Rubiaccine, $C_{22}H_{11}O_{10}$, is a yellow colouring matter, crystallising in greenish yellow needles of much lustre; it is believed not to be the only yellow colouring matter in madder; when treated with perchloride of iron it is oxidised, and forms an acid—*Rubiaccic acid*, of the formula $C_{22}H_9O_{17}$, which forms crystalline compounds. *Chlorogenine* or *Rubi-chloric acid* is a substance which, under the influence of strong acids, is converted into a dark green powder—whence its name; it is supposed to be this principle which stains the unmordanted parts of calico in the dye bath, and which, being partially removed and destroyed in garancine making, permits this latter to dye without staining the whites so much. *Pectic acid*, or *pectine*, *sugar*, and *gum* are also found in madder. Mr. Schunck points out the existence of a ferment in madder, which he calls *Erythrozym*, and which, in confirmation of Higgins, he looks upon as capable of transforming some of the uncoloured principles into alizarine. He goes further, and says that fresh madder root contains no red colouring matter at all, only a yellowish colour, which is of no technical value, but

it contains this ferment, which changes the yellow into alizarine. The principle from which all the colour is supposed to spring is called *Rubian*, and has assigned to it the formula $C_{56}H_{34}O_{30}$; Schunck claims to have isolated this principle in a pure state, and to have satisfied himself that it is capable of producing alizarine by the action of the peculiar ferment in madder, and also by the influence of acids and alkalies. Its formula differs from that of alizarine by fourteen atoms of water, one equivalent of rubian yielding two of alizarine and fourteen of water. But this reaction does not take place neatly, it is accompanied by a multitude of secondary products, which seem to indicate that sugar is produced at the same time. Here is a list of some of the bodies said to result from the decomposition of rubian by ferments or acids :—

Rubiretine,	$C_{28}H_{12}O_8$
Verantine,	$C_{28}H_{10}O_{10}$
Rubianine,	$C_{44}H_{24}O_{20}$
Rubiadine,	$C_{32}H_{13}O_9$
Rubiafine,	$C_{32}H_{13}O_9$
Rubiagine,	?

It would be useless to enter into details upon the manner in which the discoverer connects these bodies with one another and the original rubian. He does not look upon them as necessary to the reaction, and the probability is that they are accidental and indefinite mixtures of secondary products. Rubian should yield about eighty per cent of its weight of alizarine, but, owing to the formation of bye-products, not more than from ten to twenty per cent can be obtained. Besides the above-mentioned compounds Mr. Schunck describes the following, of which only the names and formulæ are here given :—

Rubianic acid.....	$C_{32}H_{20}O_{27}$
Chlororubian	$C_{44}H_{27}ClO_{24}$
Chlororubiadine	$C_{32}H_{12}ClO_9$
Perchlororubian	$C_{44}H_9Cl_9O_{15}$
Purpurine	?

The latter named substance he looks upon as a species of colouring matter, distinct from, and inferior to, alizarine, which fixes upon mordants, but is removed in the subsequent treatments to which the better class of madder colours are subjected.

Such is a brief account of Mr. Schunck's labours upon madder. It is impossible not to admire the perseverance and ability which has carried him through the examination of so great a number of difficult

compounds, a difficulty which no one can appreciate who has not had to do with the analysis of bodies of such high equivalents, and whose compounds are not always marked with that definiteness which is so great an assistance in all analytical determinations. Mr. Schunck's numerous papers are scattered throughout various volumes of the Transactions of the Royal Society, but reference may be made to an abstract of them in the Journal of the Chemical Society, vol. xii, p. 198.

Notwithstanding all that has been done, the question of the colouring matters of madder is far from being settled yet. The weight of evidence is in favour of the existence of only one useful colouring matter. There can be no doubt of the possibility of abstracting a yellow coloured matter and a pink or rose coloured matter, which are each different from alizarine. But they cannot give any of those colours for which madder is used, while alizarine can yield them all. It is not necessary to suppose the existence of a purple colouring matter, when it is found that the same crystalline product which produces a red with alumina will give the purple with iron, and when also it is known that a madder red dye can be changed into a purple or black by driving away the alumina and substituting an iron basis, and that *vice versa* the alizarine which has combined with iron to form a black can be disengaged, and form a red as if it had never been in combination. The question which has interest in technology is not so much what are *all* the constituents of madder, but what are those constituents which take part in its application as a colouring matter, either as assisting it or retarding it; exceedingly little is yet known upon this point.

There are no independent researches upon garancine or garanceux. The proximate or primary principles in the root may be considered to have been entirely altered or destroyed by the treatments necessary to convert it into garancine. It is a curious commentary upon Mr. Schunck's long and laborious researches, and shows the extreme difficulty of the subject, that this accomplished chemist is compelled to admit that, in the only case where his efforts have resulted in commercial success, he is quite unable to point out what the nature of the change is which takes place. The commercial alizarine loses weight; that is all that is known for certain upon the influence which high-pressure steam effects upon the washed madder.

COCHINEAL.

This valuable colouring matter was for a long time taken to be a berry, until closer examination of the grains showed that they were

insects, and the history of their preparation confirmed it. This insect is of the louse species, living upon a peculiar kind of tree or shrub in Mexico and other countries where it flourishes. The manner in which cochineal is obtained consists in gathering the insects from the branches and plunging them into boiling water, or water and vinegar, taking them out almost immediately. They are killed by the immersion, and then exposed to the air to dry. Two kinds are recognised in Mexico, under names which signify fine cochineal and wild cochineal. The fine cochineal may be considered as a cultivated product, its food and wants being carefully attended to, while the wild cochineal is left in a natural state and is less valuable. Wild cochineal is distinguished by having a woolly downy coat, which is not the case with the fine cochineal.

The quality of a sample of cochineal can be frequently judged of by its external appearances, especially by those accustomed to see many varieties. The best cochineal has a silvery grey colour, with a purplish reflection; it is wrinkled on the convex side in lines proceeding from a central furrow at right angles, or nearly so. The central furrow appears to represent the back or spine of the insect. But little traces of an insect can be otherwise discerned about them, but such as are visible ought to be carefully noted, as it is almost impossible to imitate them artificially in the grains which are added for adulterating purposes. Steeping them in water until they swell allows their shape to be more clearly seen, and differences between them and made-up compounds are more apparent.

Cochineal is a very rich colouring substance, yielding about half its weight of real colouring matter. This colouring matter is very soluble, and easily extracted from the insect by boiling it in water. The extract contains, besides pure colour, a quantity of animal matter, and it is liable to putrefy in the concentrated state when kept in warm places. It acquires a very disagreeable smell, but even then does not appear to be much injured in its powers of dyeing or yielding colours in printing, though it would not be safe to allow this putrefaction to continue to any considerable degree. The extract of cochineal may be boiled down to a syrupy consistence, but for general purposes it is not used stronger than about 9° Tw., and is reduced from that for most shades. The pure colouring matter of cochineal has received the name of *carmine*; it is red, soluble in alcohol and water, and, besides being itself of a magnificent colour, readily yields all those shades which the cochineal itself does to mordanted cloth.

The colours which are derived from cochineal are red, and its modifications of pink, scarlet, and crimson. The alumina mordants give the

crimson colours; they are very fine, deep, and solid shades, but have not any great brilliancy to distinguish them. The scarlet is obtained by means of a tin mordant, and no colour can compare with a good cochineal scarlet in brilliancy, fastness, and fire. The pink is obtained from a modification of the cochineal colour, obtained by boiling the insect with ammonia and water instead of water alone. Alumina is the proper mordant for it. It is a difficult colour to obtain in its best state, and as a pink has not so much beauty as safflower pink, but is very much more stable. Other shades besides these can be obtained from cochineal, but they are seldom worked, being expensive and capable of close imitation by cheaper colouring matters. The greatest affinity of cochineal is for wool; with it it yields its deepest, brightest, and fastest colours. It is applicable on silk and cotton, but the same depth of shade cannot be obtained. The greatest consumption of cochineal is in dyeing woollen cloth scarlet, but large quantities are also used in calico printing for obtaining reds of the scarlet nature, and also pinks and crimsons.

Adulteration of Cochineal: Analysis.—The high price of cochineal has induced fraudulent dealers to devise methods of adulterating it with cheaper substances. The plans which have been detected up to this time are :—

(1) Increasing the weight by moistening the insects with some adhesive substance, as size or gum, and then shaking some mineral powder, as mineral white, upon them, which adheres in a quantity sufficient to make it highly profitable. Dr. Ure states that as much as 12 per cent of heavy mineral white can be attached to cochineal in this way without creating any particular suspicion, to the great profit of the dealer and loss of the buyer.

(2) Making berries of various substances of a pasty nature, about the same size as the cochineal grains, and giving them nearly the same appearance by several processes; then mixing them with good cochineal.

(3) Using spent cochineal to mix with good cochineal: first, doctoring it by steeping in logwood or peachwood liquor, drying, then covering with French chalk powder or ground talc, to give the natural grey colour to the insects; and either selling this at a low price to dyers of low styles, or mixing it with certain proportions of good cochineal. This fraud appears to be a regular trade, and carried on so cautiously as not to be readily discovered. The sophisticators do not exhaust the cochineal too much at first, simply extracting as much colour from the cochineal as they can cold, without disturbing the appearance of the grains, then drying cautiously. A ruder class of operators purchase the spent cochineal from those printers or dyers who make their cochineal liquor from

the whole grain without grinding, and then exercise their skill in restoring it as near as possible to its original shape or form.

The tests for these adulterations are practical, but do not distinguish between a good quality sophisticated, or an unadulterated sample which is naturally deficient in power. They consist in dyeing patches of cloth with the samples offered, against samples of a known and proved quality, and judging from the results found. This is the only way of testing that shows the real value of the grain. For minute information as to how the adulteration has been effected, or what it consists in, a regular analysis is required.

John gives the following as the result of an analysis of cochineal:—

Red colouring matter	50.00
Gelatine	10.50
Fatty or waxy body	10.60
Tegumentary matter	14.00
Gelatinous mucilage	14.00
Phosphates and Chlorides of Potash, Lime, and Iron	1.50
	100.00

Pelletier and *Caventou* were the first to isolate the pure colouring matter of cochineal; they gave it the name of *carmine*, and assigned to it the formula $C_{16}H_{13}NO$. This pure colouring matter is soluble in water, and is then peculiarly susceptible to the action of saline solutions.

The colouring matter of cochineal can be brought to the colourless state; in which condition it is still soluble in water, and when exposed to the air becomes gradually coloured.

The names of *cochenilline* and *carmène* are also given to the colouring principle of cochineal. *Pelletier* and *Caventou* assert the existence of another colouring matter, which they term *coccine*; but there are no analyses of these supposed bodies.

Ammonia is supposed to act chemically upon the colouring matter of cochineal, altering its atomic constitution; but nothing certain is known of this reaction.

Of the various methods of determining the value of cochineal which have been proposed, none appear to be worthy of reliance except that of dyeing up mordanted cloth. It is possible for a practised eye to form an opinion of the comparative value of two samples of cochineal by the degree of colour which a given quantity can communicate to a volume of ammonia or ammoniated alcohol. But this is at best only of an approximative character, and should be supported by the dyeing test.

KERMES.

This substance is also of an animal nature like cochineal, and its colouring matter, chemically considered, is exactly the same. It was the cochineal of the ancient and middle ages, but the richer cochineal of the Mexican states has rendered it now a very scarce and seldom used article. It required twelve parts of kermes to dye as much as one part of cochineal. It was from this substance being in grains that the old term of 'grain colours' arose in dyeing; a grain colour was a fast and durable colour, but of course the term was abused, and many colours said to be grained which would not admit of the use of kermes; just as in this day indigo blues are sometimes sold as maddered goods, because the term maddered in its original sense expressed a class of colours faster than others. Kermes is yet used in some parts of the continent, but usually along with cochineal. It is considered as giving more durable colours than cochineal, and indeed the brightness and solidity of red colours in tapestry, ecclesiastical furniture, etc., which have been dyed with kermes, show that it was very valuable in this respect. The manner of its application was similar to that of cochineal. I do not think it is now known in England.

Lac Dye.—This substance contains the same kind of colouring matter as cochineal, and originates also in an insect. At first it was extracted from dark coloured stick-lac, but now it is partially purified before it comes to England, and is called lac-lake or lac-dye. The lac-dye appears to be a compound of the colouring matter extracted from the resinous stick-lac, with alumina; how it is prepared we are not perfectly informed, but it is likely that the colouring matter is dissolved by alkaline solutions and precipitated by alum, and that consequently the lac-dye is a lake of alumina. This explains why it does not dye without being treated with acid solutions,—it must be freed from its alumina, and this is done by the acids taking the alumina. At first sulphuric acid was employed; now the muriatic is mostly used, but not in a pure state—it contains tin dissolved in it; it is a very acid muriate of tin. Being left a few hours in contact with the powdered lac-dye it brings it to a fit state for dyeing. The preparation of the woollen cloth for dyeing resembles the cochineal process, differing only in quantities and such minor modifications as practice has pointed out to be beneficial. The colour produced is not so good as that from cochineal, being deficient in brightness and fire; but for heavy woollen material it has certain advantages, and the difference between it and cochineal is not very great in dark scarlets. It does not

yield the lighter shades, as pink, nearly so good as cochineal does. Some modification of it has been sent among printers as a substitute for cochineal, but the difference in price has not been so much on the side of the substitute as to compensate for the lesser brilliancy of the colour it gives. I believe some printers use it, but it does not give the best work, and is confined to the lower styles of printing.

SAFFLOWER.

This substance, called also *carthamus*, is the flower of a plant growing in the north of Africa, and in some other warm climates. It contains two colours,—a yellow which is loose and valueless, and a red which is very beautiful. The yellow dissolves in cold water, but the red is insoluble; and as the yellow would injure the red if the whole safflower were to be used together in dyeing, it is always washed in cold water to remove it. The red colouring matter is soluble in weak alkalies, and crystals of soda or pearl ash are usually employed to dissolve it; heat is not necessary and is even injurious, the operation succeeding best at the natural temperature. When the solution of the colouring matter is made, it is set free again by neutralising the alkali with some acidulous body: lemon juice, citric acid, tartaric acid, and vitriol are used by different dyers; it does not seem that it is of any importance which acid is used, notwithstanding all the minute directions which have formerly been given in this way, and the great importance which seemed to be attached to it. No time should be lost after the addition of the acid in placing in the articles to be dyed, for it appears that the affinity of the coloured particles for the fibre diminishes in proportion to the time of their precipitation or liberation from the alkali. The stuff to be dyed is then worked in the liquid until the colour is exhausted or the desired shade obtained. It yields shades of red from the finest light pink to a flame-coloured poppy red. Its shades can be heightened and assisted by other colours for the darker shades: as for example by anotta, turmeric, &c.; but these are not admissible for the lighter and brighter shades.

A method of obtaining finer colours is sometimes used: the red colouring matter is taken up by finely carded cotton wool from the dye tub; this is gently washed in clear water, and then the colour taken from it by crystals of soda, and the stuffs dyed in it after the addition of lime juice. It is said to give better results, but it is questionable whether it is worth the trouble. Inferior qualities of safflower might require some such treatment to give good colours, but good qualities do not.

An extract of safflower is used by dyers instead of the raw material itself; the smaller dyers prefer it as easier to manage and more regular in its results, and even extensive houses employ it. It is liable to injury by age, if large stocks are kept; the last bottles not giving the same results as the first. It is a very expensive liquor, and its mode of preparation is not generally known, being kept in the hands of a few houses as a secret.

The pure colouring matter of safflower is called *carthamine*; and having acid properties, it is also known as *carthamic acid*. Its manner of fixing upon fibre is different from that of any other colouring matter. It requires no mordant, like madder or cochineal; it does not require to be in solution, like indigo or anotta, but fixes at once, as soon as the cloth is brought into contact with it. It is a loose, unstable colour, soon changing its shade by exposure to the sun and air; more stable upon wool or silk than upon cotton. The light pink muslin dyed with this colouring matter changes its shade in the course of three or four hours' exposure to the sun; it becomes white sometimes in the course of a day. Silk suffers, but partly recovers its shade on being put up in a dark place. Cotton does not—that I am aware of—ever regain its lost colour. If it could be combined with mordants, it is probable that its colour would be faster, but it does not show the slightest affinity for mordants—dyeing up the cloth better without than with them. The peculiarly agreeable shade which safflower gives cannot be imitated with any closeness by combinations of known colouring matters. The nearest results I have yet seen are from murexide, but they want the softness and velvety reflection which is a property of the safflower pink.

The only published analysis of safflower is by Dufour, and stands as follows for a thousand parts :—

Water dissipated at a temp. of 80 Fahr.	62
Dust and remains of vegetables	34
Vegetable albumen	35
Yellow acid matters, mixed with sulphates of lime and potash	244
Extractive matter.....	42
A species of waxy matter	9
Yellow colouring matter similar to the above, but dissolved by weak alkalies	24
Pure colouring matter (carthamine)	5
Ligneous matter, insoluble.....	496
Earthy matters (lime, sand, &c.)	19
Loss	7

This is taken from Persoz : Dumas gives a slightly different account, in which mention is made of acetate and chloride of potassium, and of a

resinous matter. The original paper will be found in *Annales de Chimie*, t. xlviii., p. 285. The formula of carthamine is represented as $C_{28}H_4O_7$.

PEACHWOOD, BRAZIL, SAPAN, BAR, AND CAMWOOD.

These woods give the same, or nearly the same, colours with mordants, and do not appear to be chemically different one from another. They are not identical in their behaviour in the dye beck, but the differences seem to be owing rather to accidental circumstances than essential properties, such as the country, soil, climate, age of the tree, etc., etc.; but they are so much alike that they may in most cases be used indiscriminately.

The colouring matter of these woods is soluble in water to a large extent, but not so easily, requiring a large quantity of water and long contact to extract the colouring principles from the woody cells, but when once dissolved it may be concentrated and boiled down to almost any required degree of density. It is to facilitate this solution of the colouring matter that it is customary to heap up the ground or rasped woods under sheds, deg them with water or urine, and turn them over for several days or weeks before using them. There may be some chemical action from the atmosphere, but it is not a necessary action, since the colouring matter can be extracted at once without exposure, but not so easily as with it. The heightened colour of the woods is in great measure due to the simple wetting of them, and consequent partial solution of the colouring matter, but it is quite possible that there may be some chemical action in the shape of oxidation. The colouring matter in these woods appears to be in intimate connection with substances of a resinous nature, if even the colouring matters themselves are not species of resins. It therefore happens that the extracts of these woods when boiled down deposit a kind of tar or pitch which has been held in solution or suspension in the more diluted liquors; the quantity of this pitchy matter varies with different qualities of wood, and itself appears to contain a good deal of colouring matter.

The above woods give red colours with alumina mordants, and similar shades with tin mordants. They are used in dyeing reds on wool and cotton, and also in combination with other colouring matters, and with various mordants can yield a great number of shades. The concentrated extracts are employed in calico printing for steam and spirit colours. The reds they give are not comparable on wool and cotton to cochineal colours, but on silk they stand examination better. They

form pinks with tin salts, and mixed with other substances help to produce various shades of chocolates, browns, etc. As before mentioned, peachwood is much used in garancine dyeing.

The extracted liquors from these woods are usually preferred by dyers in the old than in the fresh state. It is imagined that some kind of fermentation goes on which refines the solution, and causes it to yield better colours. Whether this idea be well founded, or merely a prejudice, it is not easy to say; chemical science does not indicate anything as taking place in the solution which could have an improving effect. It is well known that the woods mentioned at the head of this article are not all of the same good quality, though apparently all containing the same colouring matter. Attempts have been made to precipitate, or otherwise get rid of, the impurities in the decoctions of inferior qualities of wood, so as to make them yield better and brighter colours; but these have not met with general success, perhaps a great deal owing to economical reasons. A method proposed consisted in adding skim milk to a cold and not too strong decoction, stirring it up and then boiling; a coagulum was produced, holding some of the inferior colouring matters, and the remainder of the liquor was considered as much improved for dyeing and printing purposes. It could be used immediately with as good results as liquor which had been purposely kept a long time; it is stated in addition that a slight fermentation improved it still more.

It seems not improbable that the effect of age on extracts of this class of woods consists chiefly in the throwing down of the resinous matters, but whether this is owing to any chemical change, or merely an effect of time in permitting the aggregation of the resinous matters diffused through the extract, or whether it consists in this at all, is a question quite open to dispute.

Chevreul obtained a crystalline substance from Brazil wood, which he looks upon as the pure colouring matter, or as containing the pure colouring matter, for he says that he did not obtain it in a perfectly well-defined state; he has not therefore published any analysis of it. It is said, like the other colouring matters, to be derived from a colourless principle by oxidation. It gives red and crimson precipitates with many salts. It is called *bresiline*.

CHICA.

This colouring substance is not practically employed in Europe, I believe, but there seems a probability of its being used if the supply is abundant, and the price not too high. It is prepared, by a troublesome

and complicated process, from the leaves of a tree growing in central and southern America. A sample which I examined was in small irregular lumps, of a bright scarlet colour, adherent to the tongue like indigo, and taking a metallic polish, of a greenish reflection, when rubbed against a hard smooth body, as the finger nail. So far it seems to be only used by the Indians as a paint for their bodies, mixed up with fatty matters. It has probably been employed in painting; for in the old churches of those parts of America there is a good deal of red colour, which remains brilliant and sound after a couple of centuries, and from the appearance of it, and such accounts as can be collected, it appears to be this chica. The chica I examined had been sent over to an eminent artist in England, to ascertain whether it would be of any value as a pigment in the fine arts. His report, I believe, was unfavourable; and it was then examined as to its capabilities for dyeing and printing. It was contained in a gourd, and labelled "Chica d'Andiguez." It was ascertained that it could produce fine and durable red colours upon woollen, equal in appearance to cochineal. The shades it communicated to mordanted calico were dull and heavy, but very solid. It is a very strong colouring matter, a small quantity dyeing a large amount of cloth. It more nearly resembles lac lake than anything else I am acquainted with, and gave the best results upon woollen with tin mordants. No information existing as to its price, and the probable quantity that could be obtained if it were wanted, it remains in the state of an unapplied product.

MUREXIDE.

The red colour obtained from this substance has created a great deal of interest amongst printers and dyers since its introduction, about three years ago. For purity and brilliancy of shade it was not excelled by any other colour, and, though expensive, it was easy and certain in its application. Its fugitive nature has for the present limited its employment very much, but it is to be hoped that something may yet be done which shall make this magnificent colour better able to stand the effects of light and air, when it cannot fail to be frequently and regularly employed in certain styles.

It was known, upwards of thirty years ago, that when the uric acid, obtained from guano, or other sources, was treated with nitric acid, it yielded a white crystalline substance, called alloxan, which stained the fingers and nails red, and a method is given, in Leuch's treatise upon colouring matters, by which woollen cloth may be dyed purple by

steeping it in solution of alloxan, drying, and then passing a heated iron over it. Not much more notice was taken of this matter until the year 1853, when Sacc and Schlumberger revived the idea, and communicated a paper to the "Société Industrielle de Mulhouse," accompanied by specimens of colour upon woollen cloth. There was not much in their communication that was really an advance upon the statement in Leuch, as far as regards the colouring of woollen cloth by alloxan, but there were many useful suggestions and statements, the results of an advanced chemical knowledge upon the subject of uric acid and its transformations. The authors attributed the production of the colour by the heated iron to the transformation of the alloxan into murexide, or purpuric acid; but the idea does not seem to have occurred to them to make murexide itself and try it as a colour, and they state definitely that they cannot obtain any colour on cotton cloth to withstand cold water. The sanguine authors of this communication hardly dared to look upon this subject as one which came within the limits of practical application, but rather as an interesting experiment which must be confined to the laboratory on account of its difficulty and the costliness of the materials used. The making of murexide itself, and the possible application of it as a colouring matter, would even at that time be considered as impracticable; for even as a laboratory product it was a rarity, and beyond the supposed difficulty of its preparation was the belief that its solubility and the absence of any coloured combinations of it with metals would prevent its being of any use as a colouring matter. About a year afterwards a French chemical manufacturer secured a patent, and sent abundance of murexide into the market, along with a process of applying it on calico. The first murexide sent into the market was a reddish purple powder, dissolving in water with a fine purple colour, leaving a little residue undissolved. Improvements were soon made in its manufacture, and there has been sent into the market murexide in crystals almost chemically pure, and with that green metallic reflection peculiar to this body and the wings of certain insects. There are two principal methods by which it can be prepared, but the details would be too long and inapplicable here, because it is a pure manufacturing process, and not as such specially connected with printing or dyeing.

The composition of murexide is not known with any degree of certainty; it may be looked upon as an acid body, or containing an acid, called from its colour the purpuric acid; and the purplish-red colour it produces with oxide of mercury, or a salt of mercury, may be called the purpurate of mercury. The method of obtaining the colour from

murexide can be modified in several ways; but it is usual to make a strong solution of nitrate of lead, from three to five pounds per gallon of water, thicken, and while at blood heat dissolve in it the required quantity of the murexide, from four to eight ounces per gallon, stirring it well. This colour is printed, aged a short time, exposed to the vapours of ammonia for a few minutes, passed through cold water, and then into a raising pit containing bi-chloride of mercury, or corrosive sublimate, at the rate of about two ounces to a gallon of water, and usually mixed with a small quantity of acetate of soda and acetic acid. The colour may be considered as finished, or it may be again exposed to ammoniacal vapours to give it a modified shade, or passed in dilute acetic acid. The exposure to ammonia in the first instance is sometimes dispensed with, but I do not think so good or full a shade can be obtained without it. By using acetate of zinc instead of the bi-chloride of mercury an agreeable shade of yellow is produced, but not so much esteemed as the red. This colour stands washing well in water, and is not injured by weak soaping; it retains its brilliancy for at least two years, when kept from air and light; but, unfortunately, a week's exposure to a good light is enough to spoil it, and it must be classed amongst the fugitive colours. It is quite possible that some modification of this colouring matter may be found to give more permanent colours, but it is contrary to all analogy to expect that a mercurial mordant will ever do it. All the salts of mercury are subject to decompositions in a more remarkable degree than the other salts of metals used in printing and dyeing, and even among metals of the same chemical class they are distinguishable for their inferior stability. This is the case with mineral acids, and is more remarkable still with organic acids. It would be a matter for surprise if a compound of mercury, with a highly organised body like murexide, should not be alterable under the agencies of heat, light, and air. The murexide red undergoes some molecular change on the cloth not accompanied by a change of colour, but connected with some change of form which renders it less adherent to the fabric. If a murexide coloured dress be worn a few times under favourable circumstances it will not differ much in shade from a piece of it which has been exposed to the same atmospheric influences but kept quiet. If the dress and the piece kept be subjected to washing together in cold water, the dress will be found to lose colour to a perceptible extent, the water becoming coloured at the same time; the piece not worn does not suffer to nearly the same degree. The same thing happens again, to a still greater extent; the worn dress losing much more than the unworn patch, until at a third washing the dress will have lost all its brightness

and become yellow. This seems to be owing to the movement of the fibres one upon the other, inducing a change in the form of the mercurial pigment; for it may be observed that the parts most subject to rough movement, as the lower flounces which touch the floor, are most and soonest injured. It is probable that the precipitated purpurate of mercury is crystalline in its form, and not amorphous; at any rate its behaviour suggests something of that nature, and the taste of mercury which can be perceived upon masticating a little calico coloured with it seems also to point out a degree of solubility in the compound, or else a power on the part of the saliva to decompose the coloured salt and appreciate the mercury. The red colour is easily injured or destroyed by heat, it will not sustain the action of steam, and though a little soap does not much injure it, and may in fact be employed when cold to produce a modified shade, a boiling in soap is almost destructive to it. No attempts to fasten this colour have been successful so far, and though represented by some houses as a fast colour, and sold as such, it is only in the name; there is actually no difference in the stability of the colour thus guaranteed and that ordinarily produced.

Woollen does not take colour well from murexide: it can be dyed with it, but it does not receive full and deep shades. The best colour from the uric acid products for wool is derived directly from alloxan, which is a colourless body in itself; but being dissolved in water and applied to woollen cloth, and the material hung up in a room with ammoniacal vapours circulating in the atmosphere, it takes a deep reddish purple or amaranth colour. This change can be effected more rapidly by heating the woollen, but not so regularly. The colour thus produced resists washing in water and weak soap, and is not particularly acted upon by atmospheric agency. The comparative expense of the alloxan, and the possibility of obtaining shades nearly similar with cheaper substances, will prevent this colour from being used to any great extent.

Silk receives a fine red colour from murexide. It may be communicated by passing the silk first in a bath of the bi-chloride of mercury, and then adding the murexide to the liquor; or, having two liquors, the mercury and murexide, separate, and passing from one to the other until the required shade has been obtained. The kind of red thus produced is not one in demand, and I believe is never made now. It is subject to the same influences and changes as the colour upon calico, fading and washing out like it after an exposure of a few days to the air and light.

The orange-yellow colour which can be produced from murexide, by

means of the salts of zinc being used instead of mercury, is a pleasant colour, but not remarkable. A similar and hardly distinguishable shade can be obtained in several ways preferable on the score of economy and stability of colour. It is not used.

Red Colour from Aniline.—When aniline is treated with anhydrous bi-chloride of tin or nitrate of mercury, with acids and the peroxide of lead, and oxidising agents generally, there is produced a red resinous colouring matter of great beauty. Many patents have been taken out for the preparation of this product, which is known under a variety of names, among others as Magenta, Cerise, Fuchsine, Azaëline, etc. It fixes upon silk without mordant, giving deep cherry reds; upon woollen the colour is dull; and it has no affinity for cotton, unless prepared with animal mordants. It is applied to cotton fabrics in two ways: first, mixed with albumen as a pigment colour, and applied topically; and secondly, by dyeing cloth mordanted with albumen—the albumen in both cases being fixed by steaming. It does not resist soap and exposure to the air so well as to be entitled to the name of a fast colour; but unless its expense interfere, it is likely to be much used upon muslins and the finer cotton goods. M. Bechamp assigns to fuchsine one of the two formulæ, $C_{24}H_{10}N_2O_2$ or $C_{24}H_{12}N_2O_2$, and describes it as an organic base. When isolated in the pure state, it has a brilliant metallic green colour. It is sold either as a liquid or a pasty mass. I had occasion to examine some pasty magenta which contained twenty-five per cent of mineral matter. For dyeing, the paste is dissolved in methylated spirits, filtered from any tarry matter present and mixed with water; the silk is worked in either cold or slightly warm, with or without addition of tartaric or acetic acid. For some pastes the methylated spirit must be diluted, or it will dissolve a quantity of tarry matter injurious to the colour.

Other Red Colouring Matters.—The colouring matters which have been mentioned constitute all those from which practical dyers in this country derive the red shades they produce. But there are a few others which, from their scarcity and dearness, are never employed in England, but receive an application in other countries. Our stock of red colouring matters would appear at first sight to be pretty plentiful, and sufficient to satisfy the demands of the trade. But this is really not the case. Madder is the only one which gives fast reds upon cotton cloth, and the manner of its application is tedious, uncertain, and expensive. The reds which cotton receives from the woods of the Brazil and peachwood family are fugitive, speedily changing to yellow under the influences of

wear and exposure. There is, perhaps, no colour so much wanted in the trade as a good and cheap red. Many imitations of Turkey red are in the market, more or less successful in resembling the hue of this colour, but none of them possessing or even aiming at the stability which has for ages distinguished the true Turkey red.

Cochineal leaves nothing to desire as a scarlet upon woollen cloth, but it is very expensive. Its price runs up as high as seven shillings a pound for the best qualities, and the dyer is tempted to employ cheaper substitutes; but the fine scarlet upon woollen will not permit of additions without immediate and considerable degradation of shade, whatever may be the case in other colours. The lac dye has served to relieve the pressure on cochineal; and all but the very finest shades can be advantageously obtained from it. Safflower, from its expensiveness and the fugitive nature of its dye, does not admit of extended application: it is only in the extreme fancy styles that it finds a regular place. I have had submitted to me, and partially examined, a product from Greece or Turkey, used in those countries for dyeing the red turbans. It had no name, nor was there any instructions as to how it was used. It was in the shape of berries, about the size of peas, not solid, but composed of a thin brittle shell and a powdery interior. The price asked for it was about fifty per cent higher than that of cochineal, and was in itself an argument against its use. It did not give a good extract with water: it resembles in many points the lac dye, and gave colours of the same nature as that and cochineal upon mordanted cloth. In default of exact information as to how it was to be applied, the investigation was not pushed on to the determination of the comparative value of this colouring matter and madder or cochineal. The Hindoos, who dye fine fast reds on cotton cloth, use many vegetables unknown to us; but whether these are colouring matters or preparations, or whether they are useful or simply redundant, distance and want of information leave us unable to decide.

The seeds of *Peganum Harmala* yield a red colour, which has been investigated by the French, but reported as inferior to existing reds both in brilliancy and stability. It resembles the colours of the archil and cudbear class in the method of its production and application.

Paille de mil or *African cochineal* is a substance obtained from Africa; and whether it has received its name of cochineal from its appearance or origin is not clear, but it does not deserve it from the colours it produces. It behaves more like galls and sumac than cochineal, though it does give a kind of red with alumina mordants. M. H. Schlumberger,

who examined this substance, reports unfavourably of it: the colours it yields are deficient in brightness and solidity.

There is no mineral red colour fit to be applied to cloth as a colouring matter. This is a matter of regret, as such an one similar in character to ultramarine could be profitably applied as an albumen colour. All the reds yet produced for this purpose have been deficient in richness and in covering power.

CHAPTER XXI.

BLUE COLOURING MATTERS.

INDIGO.

THERE is only one blue vegetable colouring matter known in all the treasures of nature, and it is probably the most valuable and most extensively used of all colours. There is an abundance of blue flowers in nature, but the colouring matter which they contain is so small and so fugitive that even the most careful chemical methods are not able to extract any useful blue colouring matter from them. The indigo plant, from the juice of which the colour is obtained, is not in appearance one that would promise to yield any colour at all; it is the chemical treatment of the leaves, the fermentation, the lime, and the heat, which cause the production of the indigo from substances existing in the plant. The method of extracting the indigo from the plant is long and tedious, demanding much attention and skill, and influencing considerably the value of the product. As the consumer in this country has no control over the extraction, it is not necessary to occupy space with a description of it. Indigo is received in England from several parts of the world, chiefly from Bengal and Madras, in Hindostan; from some of the islands in the Eastern Archipelago, as Java and Manilla; a small quantity from Africa, from South or Central America, Guatemala and Brazil. The quality of indigo is estimated in great measure from its origin and from its external properties. The brokers in this valuable material judge by the appearance of the lumps, their size, how they have sustained the voyage, what kind of a fracture they have, their colour, the degree of coppery lustre they have or acquire by friction, their softness or hardness, homogeneity of structure or if mixed with limy or earthy

particles, their dryness, degree of adhesion to the tongue, etc., etc. It is difficult to say what these indications stand for in the true value of the material, or how far they owe their origin to the extraneous matters always present in the indigo. There are traditional characteristics of a good indigo, formed mostly upon no sufficient basis, and trusted to by persons who have never had the opportunity of testing or knowing how far these appearances correspond with the behaviour of the indigo in the vat or in the mill. Among a number of samples, a broker who has had experience may fix upon the actual value of the majority of them, and he may be, and often is, much mistaken, estimating an inferior article at a high price, and condemning a really good sample as poor. Of course the greater experience of a broker, and his acquaintance with the peculiar appearances of indigo from the various manufacturers in the world, give him a certain intuitive power of judging by externals, but when it is known that an indigo of eighty per cent can look quite as bad by carelessness in the making as an indigo of forty per cent with careful finish; that the external characteristics depend so much upon circumstances, such as weather, nature of the soil, and skill of the extractor, and that indigo is purposely adulterated by persons who strive to imitate those characteristics accepted by the brokers as indicative of a good quality, it is easy to understand that the most experienced judge may be deceived.

Indigo may contain from ten to eighty per cent of pure colouring matter, and consequently from twenty to ninety per cent of matter which is not of the slightest use to the consumer, and which may be an obstacle in his way. The object of the buyer is only to give such a price for the indigo bought as corresponds with its per centage amount of true colouring matter. Suppose that the indigo market is in such a state that good Madras sells at five shillings the pound, and it contains half its weight of pure indigo, the price of pure indigo may be estimated then at ten shillings the pound, and according to the quantity of this present in any sample its value may be calculated; if twenty-five per cent the indigo should only be worth half a crown a pound, if it contained seventy-five per cent it would be worth of course seven shillings and sixpence per pound. If there was only some good method of estimating the quantity of real indigo in a sample, it might be purchased with as much safety and satisfaction as soda ash or bleaching powder. But there is no good method known; the pure chemical indications of an analysis are not worth more, if they are even worth so much, as those which every indigo bears upon the face of it. The methods of analysis are not to be depended upon by themselves, but if taken in conjunction

with the external characteristics, as judged by an experienced eye, pretty close results may be arrived at. The method of selling indigo does not permit a chemical examination, it only allows of the use of the knowledge which previous experiences have given with regard to the external characteristics of given qualities, and though this is valuable it is very fallible. Certain brands and qualities have a reputation for regularity and richness; they are well known and eagerly purchased at high prices; but it is in the inferior looking qualities that the speculation resides, and by venturing upon which large sums of money may be gained or lost. Such chemical processes as have been proposed, and are in use for determining the value of indigo, require a practised analyst to give results worth anything; they require also many of the apparatuses only to be found in a laboratory.

Indigo is not soluble in water, in spirits of wine to a very small extent only, in weak acids and alkalies not at all. It is acted upon by strong acids in various ways, depending upon the kind of acid used. Nitric acid dissolves it and destroys all its blue colouring power; muriatic acid acts destructively upon it, converting it into a brown powder; strong vitriol or sulphuric acid dissolves it, and changes its properties, while it preserves its blue colour; the compound formed is a commercial article known as sulphate of indigo, extract of indigo, and Saxony blue. Blue indigo cannot be dissolved by any solvent we know in its pure unaltered state; the sulphuric acid solution contains no pure indigo blue; after it has been dissolved in acid it is essentially altered. But there exists a substance called white indigo, which dissolves in weak alkaline liquors, such as lime water or soda ash; it is probable that the indigo plant contains this soluble white indigo. Before blue indigo can be dissolved it has to be changed into white indigo, and this is done by several chemical agents. The difference between the chemical composition of the blue and white indigo is very trifling, and although chemists are not quite agreed as to the nature of the white indigo, as compared with the blue, the difference of opinion is small, and it is pretty generally admitted that the white indigo contains the same elements as the blue, minus one atom of oxygen. It is deoxidised blue indigo; and the chemical mixtures which favour the solution of the blue indigo, by first turning it to white, are all deoxidising mixtures. A deoxidising mixture of itself would not be sufficient, for, although it might truly reduce the blue indigo to the white state, it would be no more soluble than before. It is necessary that the deoxidising liquid should be alkaline to dissolve the white indigo when it is formed. The common agents in use for this purpose are sulphate of iron or green copperas and lime;

the action which takes place may be described as follows:—Upon the mixture of the lime and copperas the acid of the copperas is taken by the lime, and the protoxide of iron is separated as a green slime; this oxide of iron has a very strong affinity for oxygen, and if left exposed to the air it would soon change its green colour to red by absorbing oxygen from it; it has the power of taking the oxygen from indigo when placed in contact with it, and thus bringing it to the white soluble state. If the lime is not in sufficient quantity this white indigo does not dissolve. It is necessary that there be more lime present than suffices to take all the acid from the copperas; enough, in fact, to accomplish this and make a strong lime water besides. When this exists the white indigo dissolves in the lime water, and the solution has not the least blue colour if kept out of the air; it has only a clear yellow shade when the bottoms have settled out. If the lime be neutralised, by adding a little acid, the white indigo falls down as a precipitate, not quite white but rather greyish, and if exposed to the air it quickly absorbs the oxygen which the lime and copperas took from it and becomes again blue indigo, insoluble in weak acids and alkalies.

Besides copperas and lime there are many other agents employed to deoxidise indigo and make it soluble. The following may be mentioned some of them to be referred to again more particularly:—granulated tin, protoxide of tin, crystals of tin, orpiment or sulphuret of arsenic, grape sugar or glucose, treacle or molasses, madder, and putrefied urine, with several vegetable substances which are used, or were formerly used in the hot vat. All these must be in contact with alkali of some nature, potash, soda, or their carbonates, lime or ammonia. These various matters all act by attracting the loose atom of oxygen from the indigo, and reducing it to the white state. Without alkali there may be deoxidation but there cannot be any solution. Deoxidation can only take place in exceptional circumstances unless there be alkali enough present to take up the white indigo as it is formed. (See further, *Dip Blue*, *China Blue*, etc.)

Sulphate of Indigo—This substance, which goes under many names in trade, among others, extract of indigo, carmine of indigo, soluble blue, etc., is made by treating ground indigo with several times its weight of strong sulphuric acid. The indigo dissolves in the course of a few hours, forming a blue paste, which is, of course, very acid; it is mixed with a little water, and the acid removed or neutralised by common salt or carbonate of soda; as the acid is neutralised the blue falls out as a sparingly soluble compound; it is drained, slightly washed, and then sent out for consumption. The paste contains a great deal of water.

and in some cases a large amount of salts, as sulphate of soda, common salt, etc. From each pound of indigo thirteen to nineteen pounds of extract are produced, and it follows, therefore, that there is very little of the real indigo in a pound of extract. The value of the sulphate of indigo depends upon many circumstances, but can be mostly judged of by a casual inspection; the shade or hue it shows when rubbed on a piece of window glass, its more or less watery nature, its taste and general appearance, being sufficient guides as to its quality. Sulphate of indigo is used in dyeing woollen and silk, the colours it gives are not so fast as those obtained by the blue vat; upon cotton it gives no colour at all that can withstand the action of water. It is used in printing upon woollen and silk; it is for silk the best blue parts in greens, olives, and all mixed colours; in delaine colours it is much used in giving various shades of colours, from green to grey and drab. Good colours cannot be obtained on silk and woollen from the sulphate of indigo without the presence of alum as a mordant; this seems to indicate that the indigo combines in some form or other with the aluminous basis of the alum; nothing of this kind is known to take place with the indigo before treatment with sulphuric acid. The blue colour of sulphate of indigo is soon changed and destroyed by chemical agents; potash turns it yellow, and even crystals of soda can extract it from woollen cloth dyed with it. A method of purifying the blue for the purpose of obtaining some clear fine shades is founded upon this property. The common sulphate is mixed with water, and coarse wool added to take up all the colour; the wool is then washed in water, and the colour extracted from it by crystals of soda dissolved in water, not using any more alkali than necessary; the blue dissolves, while the wool retains a quantity of reddish brown colour, which is not soluble in dilute alkalies; by adding acid to the blue solution fresh wool or silk can be dyed in it, producing clearer and finer shades than could be obtained before. It has been stated that sulphate of indigo has no affinity for cotton fibre; such is the fact, but that does not prevent its being used in calico dyeing to produce greens and other colours, out of which the blue part washes as soon as it touches water, besides being subject to fade quickly by simple exposure to light and air.

Other Blue Colouring Matters.—Besides indigo there are very few substances which give a blue colour, and none of them a pure blue, excepting those plants which really contain indigo. Thus, a blue can be obtained from logwood along with alum and blue stone, but it is not comparable either in goodness of shade or fastness with the indigo blue. A good deal of it is nevertheless produced with a foundation of real

indigo, or, upon woollen, of the sulphate of indigo. Blue shades, more or less inclined to violet, are obtainable on silk and cotton from whin-berries, elderberries, and the berries of some other trees. The general mordant is a mixture of sulphate of iron and sulphate of copper, with alum on some occasions. A species of berry, imported from Italy, is used in silk dyeing for shades of blue, said to be much employed on the continent. In various parts of the world there are used blue dyes from plants, some of which possess great stability; but we are not sufficiently informed either of the nature of the vegetable or the manner of the application of the colour, to draw any conclusions concerning them.

Woad is used in blue dyeing; it contains a little indigo, but is more useful as a fermentative substance.

INDIGO—ANALYSIS AND TESTING.

Commercial indigo is a mixture of pure indigo with various matter derived from the indigo plant, or fraudulently added in its manufacture. The three following matters appear to be inherent to indigo, being found in all, or nearly all, qualities, but are not to be looked upon as a necessary part of the colouring principle :—

(1) A red resinous body, soluble in alcohol and ether, dissolved also by strong sulphuric and nitric acids,—the former acid acquiring a red and the latter a purple colour: it is insoluble in water and diluted acids and alkalies. It sublimes in part, when heated, giving colourless crystals.

(2) A vegetable gluten, which can be removed by concentrated acetic acid, or by diluted sulphuric and hydrochloric acids.

(3) Indigo brown, obtained by treating indigo which has been deprived of the two former substances with concentrated solution of potash or soda; the alkaline liquor being saturated by an acid, the brown matter is deposited.

Besides these matters, M. Chevreul has found various substances in indigo, which he designates as follows—

- (1) An ammoniacal odorous substance,
- (2) A yellowish colouring matter,
- (3) An organic acid,
- (4) A red coloured resin,

- (5) An odorous substance,
- (6) A nitrogenised substance,
- (7) Phosphate of lime and magnesia,
- (8) Sulphate and chloride of potassium,
- (9) Acetates of lime, magnesia, and potash,
- (10) Oxides of iron and alumina ;

besides the true indigo, which was in variable quantity. It does not appear that any of these matters are essentially connected with indigo as a colouring matter: they may be considered as impurities arising from the processes and materials from which indigo is produced.

Pure indigo, for scientific or technical purposes, is obtained by making a solution of the commercial article by lime and copperas, drawing off the clear yellow solution, and agitating it in the air until it has become blue and separates; the powder collected upon a filter, washed with water and then with dilute acid to remove lime, and again with water. This is better than adding acid at once to the yellow liquid, because the indigo is likely to carry down with it some portion of the resinous and glutinous matters dissolved by the lime. The scum of a newly-set blue vat yields nearly pure indigo when treated by dilute acids. Upon a small scale, a mixture of fifty parts water, three of lime, three of copperas, and one of indigo may be used. Fritsche gives a method which is quoted by many respectable authorities as successful: it consists in taking four ounces of crude indigo in powder and the same weight of grape sugar, mixing them within a twelve-pound bottle with hot alcohol of seventy-five per cent, and then adding a mixture of six ounces of strong soda solution and hot alcohol to fill the bottle. The whole is well shaken, and after reduction has taken place the clear liquor is drawn off and exposed to the air, when the indigo is deposited in crystals, which only require to be washed with alcohol and water. This is *indigotine*, or, as we shall call it, blue indigo. If the clear solution of indigo had been syphoned off into a close bottle containing acid, there would have been a white or greyish deposit produced: this is white indigo, which, upon exposure to the air, becomes blue indigo.

The analysis of blue indigo leads to the formula, $C_{16}H_5NO_2$, and that of white indigo gives $C_{16}H_5NO + HO$. In the preceding pages the expression "deoxidised indigo" is frequently used, which is in accordance with this formula: it is taken as proved that blue indigo loses oxygen in becoming white indigo, and that the white indigo may

take up water. This is the most generally received doctrine amongst chemists, but the opinion of M. Dumas, who is an esteemed authority in all such matters, is rather different. He looks upon white indigo as containing all the elements of blue, plus an atom of hydrogen; thus, according to him,—

Blue indigo is $C_{16} H_5 NO_2$, and

White indigo $C_{16} H_6 NO_2$.

It is, therefore, not a case of deoxidation according to his view, but a case of addition of hydrogen. The weight of probability is against M. Dumas, and at present unlearned chemists may consider white indigo as simply deoxidised blue indigo.

White indigo is soluble in alcohol, ether, and alkalies, giving yellow coloured solutions. The blue is quite insoluble in these agents. Solutions of white indigo are decomposed by several salts giving insoluble compounds, which all oxidise and become blue in the air. Runge says that he has obtained sublimates from these precipitates, which were crystalline and of various shades of colour, as yellow, green, and orange.

Indigo, viewed in a purely chemical light, is a most interesting body, both on account of its composition and the numerous products which it yields to the action of other chemical bodies. It is observed that its composition may be represented by that of benzoyle added to cyanogen. $C_{14} H_5 O_2 + C_2 N = C_{16} H_5 NO_2$. It has been noticed that when benzile is heated with strong alkalies, an evanescent blue colour is produced. This and other considerations, founded upon the knowledge of the composition of large classes of organic products, have given rise to the idea that indigo may be artificially produced from some of the products of the distillation of organic bodies.

Commercial Testing of Indigo.—Many methods have been proposed for determining the commercial value of indigo by chemical analysis:—there are none of them free from grave defects, and it is only in the hands of experienced persons that they will give any reliable results.

The best method is, probably, that of ascertaining the quantity of pure indigo which can be dissolved from the sample by the copperas and lime treatment. It has the advantage of being a practical test in one sense, because it is by the copperas and lime vat that most of the indigo has to be consumed;—it has the disadvantage of being slow—requiring several days to make one determination. The indigo must be in the finest possible state of division. After well grinding it may be

heated with dilute caustic soda, which is useful in still further breaking up the aggregated granules: it is then mixed up with the lime and copperas. Not more than 100 grains of indigo per gallon of water should be taken; twice its weight of copperas, and a quantity of lime, equal to that of the copperas. The whole well agitated during twenty-four hours, and allowed to stand for a couple of days: a measured portion, having a known relation to the whole bulk, is drawn off;—the indigo rendered insoluble by agitation of the liquid in the air, treated by acid and water, weighed and dried. No determination of this kind is good unless twice or three times repeated, and with various amounts of copperas and lime. The error is always against the indigo; and how much against seems to depend upon a multitude of circumstances, difficult to understand: the chief ones being the relative proportion of lime and copperas to the pure colouring matter;—one kind of indigo requiring different proportions than another kind: an excess or a deficiency equally retaining indigo in the insoluble state.

Another test is, to make a solution of indigo as above, and dip pieces of cotton in, comparing the shades with those produced by samples of a known quality. This method is subject to all the defects of the above, and some others special to itself.

A third method depends upon the conversion of the indigo into sulphate, by digesting it for some hours with from ten to twenty times its weight of strong sulphuric acid,—diluting with water, and then testing the sulphate. It may be tested in three different ways:—

(1) By simply judging of the intensity and purity of the shade of the solution by the eye, either as compared with some other sample or some received standard.

(2) By dyeing woollen cloth or yarn in it, and comparing the intensity of the shades it gives as tested against some other samples.

(3) By decolorising or bleaching the solution with solution of bleaching powder, or of chlorine of a known strength.

Any one of those methods will, in the hands of a practical person, give some data at least approximative as to the comparative value of samples of indigo. M. Henri Schlumberger appears to have considered the last method,—that of bleaching the sulphate of indigo, to be capable of considerable accuracy by paying attention to several points of detail. M. Chevreul considers that no reliable result can be obtained unless two or more independent methods are used, in order to control

one another. As, for example, the mean of a determination by the first method; and one, of the same indigo, by the last method, would be more likely to be true than either separately; because the first is always below the truth, and the last always above the truth. How far truth is likely to be hit by the balancing of two untruths I do not pretend to know. There is certainly no connection between the probable plus or minus errors from two such independent processes, and it is just an accident if the mean gives the correct result.

According to Schlumberger the finest Java indigo may contain from 85 to 95 per cent of pure indigo blue, inferior qualities of Java from 56 to 80 per cent; the average of twenty samples being above 80 per cent: Bengal indigo is represented as of about the same average value, one sample, however, selling at a low price, contained only 45 per cent of pure indigo. Bombay, Manilla, and Madras indigo are of a lower quality, averaging about 40 per cent, but varying between 27 and 55 per cent. I am inclined to think that M. Schlumberger has in every case over-estimated the quantity of pure indigo in the samples he examined.

Indigo and Sulphuric Acid.—The researches of chemists have not left it clear as to what is the precise action of sulphuric acid upon indigo: a combination takes place between the acid and colouring matter, but whether the acid is there as SO_3 or in some other form, is far from being agreed upon. According to Berzelius the action of concentrated sulphuric acid upon indigo results in the production of three copulated acids, to which he has given the names of

Sulphoindigotic acid,
Hyposulphoindigotic acid,
Sulphopurpuric acid,

the formulæ of these are not definitively fixed; the sulphoindigotic acid which is the chief product, may be represented as $\text{C}_{16} \text{H}_4 \text{N}_2 \text{O}_8 \text{S}_2$; the sulphopurpuric acid has, according to Dumas, the composition $\text{C}_{22} \text{H}_{10} \text{N}_2 \text{O}_4 + 2 \text{SO}_3$, but the idea that the compound contains either sulphuric acid or indigo (even in an allotropic form) as such, is not in accordance with the decompositions of the acid. No indigo can be reproduced from it under any circumstances. Commercial extract of indigo may be considered as a mixture of the above acids, sometimes combined with soda or potash (neutral extract).

Berzelius has observed that when sulphoindigotate of potash is treated

with 50 times its weight of lime water it goes successively purple, scarlet, brown, and yellow ; this change of colour, he says, is accompanied by the formation of four new acids, which may be separated at different stages of the action, he calls them—

Purporosulphuric acid,
Flavosulphuric acid,
Fulvosulphuric acid,
Rufosulphuric acid ;

the production of a scarlet colour from indigo is highly suggestive.

CHAPTER XXII.

YELLOW COLOURING MATTERS.

QUERCITRON BARK.

THIS colouring matter, as its name indicates, is the bark of a tree growing in several parts of America. It was introduced into England at the close of the last century, by Dr. Bancroft, well known for his treatise on "Permanent Colours." It soon came into use, as being cheaper and stronger than the yellow colouring matters then known in the trade. It is sold in the ground state, has a yellow colour, a bitter taste, and a peculiar smell. It dyes up good yellows upon wool and cotton,—on the first with a tin mordant, and upon the second with an alumina mordant. The colouring matter is very soluble in water, and is much used for steam colours, under the name of bark liquor; its principal use in this respect being for compound shades, from dark chocolate down to the lightest drabs, greys, etc. Its yellow, either by itself or with blue in forming a green, is not liked so much as that which can be obtained from other sources. With iron mordants it gives shades of grey, olive, and black, not good in themselves, but which combine well, and modify the shades produced by other dyewoods. The ground bark is liable to adulteration with mineral matters and worthless vegetable substances, the manner of detecting which are the same for all colouring matters, and have been before alluded to. Bark is much used in garancine dyeing. When quercitron bark is mixed with sulphuric acid and water, then steamed, as in the making of garancine, a product is obtained which has somewhat higher powers of dyeing than the original bark. This method of treating bark has been followed in some places, but is of no real advantage, and is now quite abandoned.

A crystalline yellow substance can be separated from the solution of quercitron bark, which is believed to be the pure colouring matter ; it is called *quercitrine* or *quercitric acid*, because it appears to possess decided, although weak, acid properties ; it is volatile without decomposition ; its formula is $C_{16} H_8 O_9 + HO$; it forms a compound with oxide of lead, which has the formula $C_{16} H_8 O_9, Pb O$. Chevreul considers that quercitron bark contains also red and brown colouring principles, but they have not been isolated. The commercial value of bark can be approximately ascertained from comparison of the depth of colour of an alcoholic infusion of it, or more correctly by the usual process of dyeing with it.

WELD.

Weld was the chief yellow dyeing substance in use before the introduction of quercitron bark. It is a reedy plant, growing in most parts of Europe, and was sold in the sheaf like straw ; the whole of the plant was used for dyeing, but the chief residence of the colour was in the leaves and upper extremity. It gave up its colour to warm water, and dyed yellows on alumina mordants. The shades it produces are superior to those from bark, clearer, and more of the lemon shade. It was tolerably permanent ; I have seen yellows from it forty years old, very good and bright. It is more expensive than bark, which is the reason why it has almost disappeared from the English market. This colouring matter was examined by Chevreul, who found in it the following substances :—

- (1) A viscous azotised matter,
- (2) Another azotised substance,
- (3) Luteoline, or pure colouring matter,
- (4) A reddish yellow colouring matter,
- (5) A saccharine substance,
- (6) A colourless bitter principle,
- (7) An odorous matter,
- (8) A free vegetable acid,
- (9) Several mineral salts of potash, lime, and magnesia.

Luteoline, the pure colouring matter, is capable of sublimation ; it has an acid character, and is soluble in alcohol and ether. It has not been analysed.

PERSIAN BERRIES.

Persian berries, Turkey berries, and French berries are all of the same species. They differ a good deal in quality, some kinds being worth twice as much as others, but they have all the same general character. The colouring matter is very soluble in water, and when concentrated, possesses a peculiar fruity smell. It yields the purest yellows in the way of either dyeing or printing. The mordants may be either tin or alumina, according to the desired shade or nature of the cloth. In silk and calico printing it is used as the yellow part of greens, and enters into the composition of other colours where the shade it produces modifies those of other substances. It has been a little used to obtain a yellow orange in garancine work. A mordant of acetate of tin was printed in conjunction with the regular colours, and a quantity of ground berries added to the dye, which, as usual, contained garancine, bark, peachwood, and sumac. It is a pleasant shade but very loose, and the excess of yellow dye in the beck turns the chocolates and reds towards that shade. Its pure colouring matter has the name of *Rhamnine*, from the botanical name of the species.

According to Kane there are two distinct principles in these berries, one existing in those which have been gathered before arriving at maturity, and the other found in the fully developed seeds; the one which is found in the unripe berries he calls *Chrysorhamnine*, the other *Xanthorhamnine*,—the latter is simply an oxidised product of the first, as may be seen from their formulæ—

Chrysorhamnine is $C_{23}H_{11}O_{11}$

Xanthorhamnine... $C_{23}H_{12}O_{14}$

FUSTIC.

This is the most generally and extensively used of the yellow colouring matters. It is the wood of a tree, soft in its nature and readily rasped. It seems to contain two colouring matters, one which dissolves in water, and another of a resinous nature which does not dissolve unless in alcohol or alkalies. There are several varieties of fustic, some of which are much stronger than others. A kind called "bag fustic," which is dark coloured and hard in the wood, is the most powerful, being apparently twice as strong as the ordinary yellow kind.

Fustic is considered to be improved by wetting with water and stale urine for some days before it is used. Fustic gives permanent colours to woollen; it combines well with the blue from sulphate of indigo to give green, and, by mordanting with copperas, etc., it can be made to yield many good shades of drabs, olives, browns, etc. Fustet is the name of some dyewood of similar and perhaps identical properties, used by the French dyers. The yellow wood of the French dyers corresponds with the old fustic of the English: their fustet appears to be derived from another kind of tree, but it is not known in the English market under that name. Perhaps that quality known as "bag fustic" may be the French fustet.

The supposed pure colouring matter of fustic is *Morine*. The substances which Chevreul extracted from this wood did not appear to him to be pure or simple principles, and he gave them the name of *Morin*. He found morin in three different states—colourless, yellow, and reddish. They have never been analysed, and it remains uncertain whether they are independent bodies or connected together by any simple link. It is possible to test the commercial value of fustic by comparing the colours of an alcoholic tincture of a given quantity of it and a standard sample.

Turmeric.—This yellow colouring matter is the root of a plant growing in the East Indies. It is mostly sold in powder, and may be easily adulterated. Its colouring matter does not dissolve easily in water, but very easily in alkalies, in alcohol, and ether; which seems to demonstrate that it is of a resinous nature. Turmeric gives yellow on silk without any mordant, and is principally employed in silk printing and dyeing; it is also used by woollen dyers in compound shades. It is a weak, fugitive colour. John has given an analysis of this colouring matter, which, like all his analyses of colouring matters, conveys little or no information. It stands as follows:—

Volatile oil of a yellow colour	1
Yellowish brown resin	10 to 11
Extractive brown dyeing substance	11 „ 12
Grey gummy matter	14
Substances soluble in alkali	57
Salts, moisture, and loss	7

100

The pure colouring matter is called *Curcumine*: it is very easily acted upon by alkalies, which change its colour to brown. Turmeric paper is

used in laboratories as a test for alkalies. The analysis of curcumine, as found in Dumas, is given thus :—

Carbon.....	69.5
Hydrogen	7.4
Oxygen	23.1
	100.0

No formula has been assigned to it.

Saffron.—Saffron cannot be said to be a regular colouring matter, being mostly used for other purposes, but it contains an intensely yellow principle, not soluble in water, but soluble in spirits, oils, etc. It is used to colour confectionery and varnishes, and is sparingly used in topping thread dyed yellow with chrome and lead. It is not a fast colour, but used in this last way it communicates a very desirable shade to thread for fancy articles.

The pure yellow colouring matter of saffron has not been separated in a sufficiently pure state to be analysed. It has received the name of *Polychroite*.

Picric Acid.—This is only lately introduced as a dyeing material for silks and woollens : it has no affinity for cotton. It is made in various ways, but always through the agency of nitric acid upon some organic matter. The cheapest source appears to be one of the oils separable from coal tar, called carboic acid, but many other substances can yield it. It is a yellow crystalline powder, of an intensely bitter taste, not acid to the tongue. It is very combustible, and the compounds which it forms with potash and other bases burn like gunpowder. It dissolves in warm water, communicating a fine yellow colour to it, and dyes wool and silk of a beautiful canary yellow without any mordant being required. It has been largely used in Lyons for silk dyeing ; upon woollen its colour is too weak and transparent. It is a powerful colouring matter ; one part giving a yellow tinge to more than one hundred times its weight of wool or silk. Silk dyed with picric acid can be detected by masticating it, when the peculiar bitter taste of this acid can be perceived. It does not work well with other colours, overpowering them and destroying them. Besides the name of picric acid it is known in chemistry as *carbazotic acid* and *nitropicric acid*. Its chemical formula is $C_{12}H_2N_3O_{13} + H_2O$.

Other Yellow Colouring Matters.—The number of yellow colouring substances in nature is very considerable. While it is an exceptional case to find a red or a blue colouring matter in the vegetable kingdom, it is almost as exceptional to find any plant which will not at some stage

of its life or decay give a yellow colour. Yellow seems to be the ultimate result of all colours exposed to natural agents, or, at any rate, the step which precedes complete whitening. But only a few plants contain the yellow principle either in sufficient quantity or in a state of sufficient purity to make it available for use. But it happens that there are several substances besides those mentioned in the preceding pages which are used as yellow colouring materials in various parts of the world. Their employment depends upon local circumstances, and they are not of sufficient interest to make it worth while describing them at length : among them, however, may be named *dyer's broom*, *the flowers of the acacia*, *juice of aloes*, *gamboge*, *camomile*, *nymphaea alba*, used in garancine dyeing in Bohemia and Germany, *willow leaves*, and various other roots, leaves, and barks. Anotta may be reckoned among the yellow colours, but it has been described as an orange colouring matter.

CHAPTER XXIII.

COLOURING MATTERS YIELDING BLACK COLOURS.

LOGWOOD.

Logwood is the wood of a tree flourishing in Mexico and the adjacent parts of America. It arrives in Europe in large pieces, and is rasped by machinery into small fragments fit for dyeing or extracting the colour from. The colouring matter requires a large quantity of water to dissolve it, but when dissolved, can be concentrated or boiled down to any degree of concentration. During the boiling down of logwood extracts and especially during the cooling, a considerable quantity of tarry matter is deposited, the nature of which is not well known—probably it is similar to the resinous substances which exist in many species of woods. A weak solution of logwood in pure water has a yellow colour; when strong it has a reddish colour, a sweetish astringent taste, and a peculiar odour. Chemists consider it contains either two colouring matters, or one colouring matter in two distinct states of oxidation. Like indigo, it is supposed to contain a colourless body which, by the absorption of air or ammonia, becomes coloured; but this statement is by no means so well proved as to be taken for a fact. The wood is very hard and dense, and as before stated does not yield its colour quickly to water. The rasped logwood is usually damped and kept in that state for some weeks before it is used, being turned over when it shows any inclination to heat. Instead of degging it with pure water, sometimes lant or stale urine is used, either alone or mixed with water. It is considered that logwood is improved in dyeing power to the extent of fifty per cent by this process; or that ten parts of it thus treated are equal to fifteen taken in the dry state from the rasping mill. It has been attempted to prove that some chemical change takes place in the colouring matter of the logwood; that the colourless principle, supposed to exist in the wood,

absorbs oxygen and ammonia, and becomes coloured, and thus its dyeing power is increased. I consider that there is no real foundation for this belief, and that the action of steeping and ageing logwood may be simply and sufficiently explained on physical grounds. The water may be supposed to soak gradually into the hard fibres, swell them out, soften the mass, and render the colouring particles accessible to the action of liquids, and so readily soluble in them. The change of colour from the dusty yellow rasped wood to the reddish hue of damped wood may be due to the simple effect of water dissolving the colouring matter, and covering the fibrous part with it; but water always heightens the hue of colouring matters. The use of urine—if it has really any use upon the wood beyond that of increasing its depth of colour—may be looked for in the action of the ammonia it contains upon the resinous matters of the wood: it would dissolve them in part, and set at liberty the colouring matters which it may be supposed they would otherwise prevent from coming into contact with the water. Solution of logwood has an inclination to form blue compounds with mineral substances, such as lime, baryta, copper, alumina, iron, etc., but if in large quantity the blue becomes so intense as to be considered a black. No good blues can be obtained from logwood, the best of them are dull and absorbent, and inclined to go brown or black; it is principally employed in dark colours, black, chocolate, etc. The pure colouring matters which may be extracted from it have received the names of *hematoxyline*, *hematine*, and *hemateine*; for an account of which see further.

Logwood is very extensively used in the black dye for silk, woollen, and calico; its cost comes considerably under that of galls, which give the best and firmest colours. Upon calico the mordant may be either alumina alone—but that gives a black too much on the purplish side—or iron alone, but the black from this will be too brown and dull. Perhaps the best mordant is a mixture of the two, in which the alumina predominates; other dyewoods are used to modify the shade of the black, according to the requirements of trade. Wool is dyed black in various ways, mostly with a blue foundation, which, for fast colours, is from the hot vat, but more frequently from the sulphate of indigo. Logwood black withstands washings pretty well, and is not much injured by a moderate soaping; it does not withstand the action of the air and light, but soon loses its lustre, becoming brown and faded. This change takes place more quickly upon cotton than upon silk, and sooner upon silk than upon wool. A logwood black can be discovered by the action of weak spirits of salts upon it; a drop turns it to a bright red. If the black be from galls, it changes the colour, but does not give a red. The

substitution of logwood for the astringent substances in dyeing black has been injurious to the general character of the black dye. For printing blacks on calico or wool the logwood is mixed with nitrate of iron. Logwood liquor is much employed in steam and spirit colours, for other colours besides black. With tin mordants it yields shades of purple, lilac, and violet; mixed with other coloured extracts it helps to produce chocolates and similar colours. Logwood produces an intense black with chromate of potash under certain circumstances, and this salt is occasionally employed in logwood colours, but it has several difficulties attending it. It coagulates the solution, and then it is impossible to work it; the only way in which, at present, it can be used is to pass the pieces printed with logwood colour through it. It gives a harshness to the pieces, and is seldom employed; but it deserves the attention of dyers, because the blacks thus made seem faster than blacks produced from iron and alumina mordants.

Logwood is a very rich colouring matter, and, under chemical treatment can be made to assume several different and valuable shades of colour, but they are very unstable, and peculiarly susceptible to the destructive action of air and light, while they withstand washing with tolerable firmness. Chemistry does not at present give the slightest clue to the reason why one colouring matter is fast and another fugitive, why one can resist the detergent action of soap and another cannot, why one is not particularly affected by exposure to the air and another is almost destroyed. There is, doubtless, some general law governing these things. It may reasonably be expected that, when the principles of the fixation of colouring matters are better understood, something may be done to communicate to the fugitive colouring matters some of that permanency which distinguishes the minority of the substances employed by the dyer and printer. Logwood seems to be one of those substances most likely to reward the labour which may be spent upon it in the endeavour to improve its permanency. M. Chevreul, in his examination of logwood, found that it contained—

- (1) Woody fibre,
- (2) Hematine, the pure colouring principle,
- (3) A matter allied to hematine,
- (4) An azotised substance,
- (5) A volatile oil,
- (6) A resinous matter,
- (7) Acetic acid,
- (8) Mineral matters.

The pure colouring matter is called *Hematine*, but more generally and preferably *Hematoxyline*. It is a yellow coloured substance, of definite composition, and has the formula $C_{40}H_{17}O_{15}$; it does not acquire the characteristic red colour of logwood until it has absorbed oxygen, which it does best under the influence of ammonia, but the ammonia does not necessarily enter into its composition. The coloured product, which is distinguished by the name *Hematène*, has the formula $C_{40}H_{15}O_{16}$, and is supposed to be formed from hematoxyline, by the absorption of three equivalents of oxygen, accompanied by the formation of water, as expressed by the equation $C_{40}H_{17}O_{15} + O_3 = C_{40}H_{15}O_{16} + 2H_2O$. There appear to be several different hydrates of hematine, of well defined composition; and a compound of hematène with ammonia, which bears the formula $C_{40}H_{22}N_2O_{17}$, equivalent to an atom of hematène with two of ammonia and one of water.

The colouring matter of logwood is distinguished from that of the caesalpinia tribe by giving blue coloured precipitates with the alkaline earths and several metallic solutions, while the red woods give precipitates of a crimson hue. The fixed alkalies, in contact with air, appear to have the power of developing a red colour from the yellow hematoxyline; this property is possessed by lime water, and also by bicarbonate of lime.

GALLS.—GALL NUTS.

This valuable dyeing substance is produced from the juices of certain trees, which are caused to exude by the puncture of an insect laying its egg in the bark, and which, drying-up, form a round, nut-like ball, enclosing the egg. If the egg becomes hatched the insect eats its way out, which explains the round holes and hollowness of some galls. If the egg does not come to maturity, or the gall nut is taken off before the time has arrived for the insect to eat its way out, the nut remains solid apparently, but really soft and spongy in the centre. There are many kinds of galls in the market, of different values, according to the place where they were produced, their age, state of preservation, etc. Aleppo galls are usually esteemed the best, and they are divided into different qualities, according to size and colour, and known as white and black or blue galls. Galls from other countries have usually a less value in the market.

The active principle in galls is an acid called tannic acid, and the value of any particular quality depends upon the quantity of this acid present. The best galls contain about three fourths of their weight of

it, and inferior galls may not contain more than one tenth of their weight. The method by which the quantity of tannic acid can be determined is one for the laboratory, and is described further on. The practical man will be enabled to form a good idea of the quality of galls from their appearance when broken, and their greater or less weight in a given bulk. In the colour-house a practical test is to make gall liquor from a certain weight of them, and to try this against a known quality in chemical black. Galls are used in dyeing silk and woollen of a permanent black; in steam and spirit colours upon silk, woollen, and cotton; and in dyeing for producing many shades of drab, olive, grey, etc. Their use has been greatly affected by the substitution of cheaper drugs, as logwood, sumac, and catechu; but none of them give as good or as fast colours as galls. Galls cannot in strictness be said to contain any colouring matter; it is, more properly, a colouring principle which, in contact with certain mordants, produces the colour for which it is used. Thus the solution of galls has only a dull yellow colour, and the tannic acid, to which its active properties are due, is nearly colourless. With alumina mordants it only gives faint shades of grey; it is with the iron mordants that it gives fast and durable blacks. The tannic acid appears to have a direct affinity of itself for fibrous matters, and to be able to accumulate upon them to a considerable extent, increasing the weight and altering the physical properties of the fibre. It appears also to form combinations with colouring matters, and to fill the place of a mordant. Where galls and similar substances can be used with advantage in dyeing, their action seems to extend beyond the share they have in contributing to the depth of colour, and to consist also in causing the fibre to take up more colour, and to form a more intimate combination with it, and one more capable of resisting the action of soap and atmospheric influences. It is on account of this property that galls and sumac are employed in Turkey red dyeing, and in other cases of madder and garancine dyeing.

Tannic acid, when exposed to the air, passes gradually into another acid body called gallic acid, which, though similar in some respects, differs to a considerable extent in others. A weak infusion of galls soon loses power by undergoing a kind of fermentation, which facilitates the conversion of the tannic acid into gallic acid; strong gall liquor does not change so rapidly. In making extracts of galls which have to be kept for any length of time, the French writers advise the use of as little water as possible in making the extract, because then the tannic acid is dissolved, and the fermenting matter left behind. M. Persoz states that if the gall liquor be raised to the boil, and kept in well closed bottles

quite full of liquor, it will not be injured in the course of three years. Gallic acid can give colours to mordanted cloth, but they are decidedly weaker and more fugitive than those derived from tannic acid. Most substances which contain tannic acid contain also a portion of gallic acid, which may be considered as a product derived from the tannic acid. There are some substances in which the gallic acid exceeds in quantity the tannic, and from the fact of these being unsuitable to replace galls in dyeing, it may be concluded that gallic acid is not of much use in dyeing. Neither pure gallic nor tannic acids are used in the arts.

Analysis.—Guibourt has made an examination of the whole gall nut, and he represents it as being composed of the following matters:—

Tannic acid.....	65.0
Gallic acid	2.0
Ellagic acid.....	} 2.0
Luteo-gallic acid	
Chlorophyll and volatile oil.....	0.7
Brown extractive matter	2.5
Gum	2.5
Starch	2.0
Ligneous parts	10.5
Saline matters and water.	12.8
	100.0

The value of gall nuts depends entirely upon the amount of tannic acid they contain. The quantity of this acid can be determined by treating the bruised galls, in a proper apparatus, with aqueous ether. Other methods have been proposed, but I believe they are not to be depended upon. The practical test is the only reliable one. Tannic acid, or tannin, has very feeble acid properties; it has a powerful astringent taste; it forms compounds with bases the composition of which are not well known, but which seem to indicate that it is a tribasic acid. Its formula is $C_{18}H_5O_9 + 3HO$. Artificial tannin, or substance similar to tannin, have been several times produced by the action of nitric acid upon organic substances, but they have not been put to any practical use. Tannic acid in contact with alkalis and the air is rapidly destroyed, probably by oxidation; one of the products of its destruction is gallic acid.

Gallic acid has the formula $C_7H_5O_3$; it is an irregular and apparently accidental accompaniment of tannic acid in gall nuts; it is decomposed by the air and alkalis even more rapidly than tannic acid. Both these acids give black or dark blue colours with persalts of iron. *Ellagic* and *Pyrogallie acid* are produced by the decomposition of gallic acid; they have no application or interest in the art of dyeing.

Sumac.—This colouring matter is the ground up leaves and small branches of a shrub which grows in many parts of the world. That which comes from Sicily is the most esteemed, and brings the highest price, but several other countries produce an useable article. It has a greenish yellow colour, bitter astringent taste, and, when good, a smell reminding of tea, or sometimes of new hay. Its quality can be judged of by its colour to a considerable extent; it should be bright and clear: some samples are dull and have a brown faded look, these are nearly always inferior. The difference of shade can only be discovered by an experienced eye, or when there is a good sample to compare with.

Sumac has the same chemical properties as galls, containing the same acids, tannic and gallic; but in addition it has a certain amount of yellow colouring matter, which, though nearly worthless in itself, modifies its effects upon mordanted cloth. Sumac being much cheaper than galls is extensively employed as a substitute, and in dyeing it answers the purpose very well, but in printing it as an extract its yellow colour would interfere too much with the effects of the tannin matter contained in it. Sumac is used as an addition to the garancine dye. It is employed in the production of many shades of colours in dyeing as drabs, olives, greys, etc. There are no reliable determinations of the quantity of the various principles in sumac. Davy has certainly given some results, but the method he pursued was not likely to yield trustworthy numbers; his statement is as follows:—

Sicilian sumac contains	 16.2 per cent tannin,
Malaga sumac contains	 10.4 per cent tannin,

while he gives gall nuts as containing 27.0 per cent of tannin, which is below the truth, even for very inferior qualities.

Other Substances Similar to Sumac.—This class of dyeing materials of which galls and sumac are the type, are called astringent substances. There are many of them in nature; some of which contain a sufficient quantity of tannic acid to make them useful, but the greater part are very poor in it, and scarcely to be used with safety. *Oak bark, pomegranate, divi divi, bablah, etc.*, may be mentioned; catechu also belongs to the same class, but it does not contain tannic acid, nor yield black colours. The tannin matter which it yields to chemical extraction is found to be different in property and characteristics from that which is obtained from galls and sumac, sufficiently so to cause it to be distinguished by another name, japonic acid, but still having greater resemblance to it than to any other body.

CHAPTER XXIV.

SUBSTANCES YIELDING MIXED COLOURS : BROWN, ORANGE, PURPLE,
GREEN, ETC.

CATECHU.

THIS substance was formerly supposed to be of mineral origin, and went under the name of Japan earth. It was long known in medicine before it became cheap enough to be applied in dyeing and printing. Its first applications in calico printing are not more than between thirty and forty years old. It was used in combination with madder colours. Its application was kept secret for a while by the one or two houses who used it, and much skill and ingenuity were wasted by others in endeavouring to discover the new *mordant* which it was thought had been used to obtain this brown shade from madder. Its application in madder and garancine styles has been of the greatest service to the trade. It has allowed a scope of design and a variety of colouring which has done much to extend the use of printed goods. In dyeing it is largely used to give various shades of brown, and the lighter colours which spring from it. Catechu is the dried-up juice of certain trees, from which it is obtained either by natural exudation or through cuts made for the purpose. It is a resinous looking body, dark on the exterior of the lumps, but light coloured within. Its quality varies very much, not only from differences in its origin and method of collection and drying, but also because it is susceptible of alteration by age, and especially by moisture. Soft and uniformly dark coloured catechu is reckoned inferior. It should be brittle enough to break upon the stroke of a hammer, and the interior should not be pitchy coloured or soft, but rather of a buff or cream colour, somewhat fibrous and capable

of being scraped into powder with a knife, without adhering to it. Though these are the external characters of a good quality of catechu, there are good samples which vary in appearance from this; the colour may be darker and the consistency of the mass less brittle, so that a knife does not scrape it. That depends upon several circumstances of the carriage and storing of this drug, and must be decided upon according to the judgment and knowledge of the examiner. The chemical characteristics of a good catechu are unfortunately not very well defined. It ought to be all soluble in hot water, and then have a brown, not blackish, colour. It ought not to be all soluble in cold water, for that is an indication of heating and partial decomposition of the catechu; and the hot water solution should, upon cooling, deposit a portion of the catechu in a fine granular state. The only actual and reliable test for the quality of catechu is to make some colour from it, or to dye up samples from it in comparison with a known quality.

Catechu is one of the astringent or tannin substances, but not of the same kind as nut galls. Its acid is called *japonic acid*, and possesses different properties and characters from the tannic acid. The method of application of catechu in calico printing shows it to be very different from most other colouring matters. For the purpose of obtaining browns it is mixed with sal-ammoniac and nitrate of copper, sometimes the acetate being used instead. From this it would appear that copper is its proper mordant, but the copper is not so much an actual mordant as it is an agent for effecting a chemical change in the catechu. The copper salts by themselves are oxidisers of colouring matters, and when mixed with sal-ammoniac their oxidising powers are greatly strengthened, in a proportion indeed far beyond the amount of oxygen which is present in the whole of the copper salt used. They act as a medium for obtaining oxygen from the air and transferring it to the catechu, which of itself absorbs oxygen in a very slow manner. The effect of this oxidising upon catechu is to change its properties, to give it a great hold and affinity for the fibre of the cloth, and to render it insoluble and unacted upon by water. Some of the copper remains combined with the colour, but the greater part is removable without injuring the fastness or shade of the catechu brown, a fact which seems to point out that catechu can fix itself without a mordant. Such is really the case, but the length of age necessary is excessive and impracticable. Even with copper salts, when it is desired to get dark shades from catechu several days' ageing are required; lighter shades take less time. Iron and alumina mordants do not give agreeable colours with catechu in printing, but several shades can be obtained by dyeing a mixture of such

mordants and catechu in madder and garancine; the resulting colour being a mixture of the catechu shade itself and that which has been produced by the mordant and dyeing material used. Muriate of iron and catechu give shades of drab, stone, and grey, when dyed up in garancine. Acetate of alumina, red liquor, and catechu give shades of red brown, varying for the different amounts of red liquor in a certain quantity of colour. Mixtures of catechu with salts of manganese and other mineral matters are in use. In dyeing with catechu, alum mordants are mostly employed. Iron and tin salts can be used to obtain various shades, copper being but little used in these cases. The bichromate of potash has a powerful oxidising action upon catechu; it cannot be applied mixed with it, because it combines with the catechu, rendering it insoluble and curdy; but a solution of bichrome can be used to pass catechu colours in. It fixes them and makes them darker. Soda and potash are also used to raise catechu colours in dyeing; their action seems to be an oxidising one, enabling the catechu to absorb oxygen with so much the greater rapidity from the air, and become fixed upon the cloth. The affinity of catechu in its altered or oxidised state for the fibre of cotton is very great. It is one of the most difficult of all colours to discharge from the cloth. It is valuable in calico printing, because it is fast enough to stand the dunging and dye beck, and all the subsequent clearing operations. It suffers, of course, in passing through all the various operations, but still sufficient is left to form good colours. It is usual to add a little bichrome to the dunging to help the catechu, but this is rather dangerous for the other colours, and should not be used except the circumstances have compelled the goods to go to the dye with a deficient age. If time enough can be given to catechu colours, the addition of bichrome to the dunging is not necessary; but in cases of heavy browns, which have only had two or three days' age, it may be used with advantage. Those shades of drab, etc., in which the proportion of catechu to a gallon of water is only small, require no longer age than the other colours they go with, and no chrome in the dung. Bleaching powder solution should be very sparingly and cautiously applied to catechu styles, it soon takes the top or bloom off the colour.

The use of large quantities of nitrate of copper in colours is very disadvantageous in printing, and it is much to be desired that some milder oxidising agent could be discovered for catechu. It compels the use of composition doctors, and even acts upon them. A resist brown containing lime juice or citric acid is very difficult to work, on account of its corrosive action upon the doctor, and consequent scratching of the roller. Without any acid the regular brown will resist light covers, but

not heavier ones, and I believe the difficulties in the way of printing such an acid mixture have caused the abandonment of this style almost altogether. I have tried many chemical mixtures instead of copper, but none of them gave any results worth following up. The applications of catechu are still limited, and its chemical properties but little known. It offers a good field for the exertions of those who have leisure and knowledge of colouring matters, for it is doubtless capable of many more valuable applications than it has yet received.

VIOLET AND PURPLE COLOURING MATTERS.

ARCHIL.

Under the names of archil, cudbear, and litmus, a colouring matter is found in trade which is extracted from several species of lichens by lengthy and complicated operations. Of archil there are two varieties the red and the blue; it is either in a liquid or a paste. Cudbear is in the state of dry powder; litmus in blue cakes. They have each a peculiar smell, partly owing to the ammonia used in their manufacture, and partly derived from some principle peculiar to them. The colouring matters of litmus, cudbear, and archil, are nearly, if not quite, identical. They have a beautiful rich reflection about them, but are peculiarly susceptible to the destructive action of air and sunlight. Their principal use is in silk dyeing, where they yield various shades of blue, peach, violet, etc. In woollen dyeing they are also sparingly employed. In printing woollen, archil is used for several colours; it gives a very full chocolate, and may be made to yield fine dahlia shades. Archil is said to be used to give a bloom or to top several dyed colours of deficient depth or goodness; of course it soon disappears upon wearing, making manifest the defects of the real dye. The application of archil to calico has not met with much success. Some interest was created in 1850-51 by its yielding fast dahlia colours through means of a preparation of the cloth with caseine, an animal matter from milk. The colour itself left little to desire for brilliancy and softness of shade, but everything on the score of stability. Notwithstanding the asserted efficacy of the animalisation of the fibre, the dahlia shade would neither stand soaping nor a day's sunshine. It was, moreover, very expensive, costing from ten shillings to fifteen shillings to prepare a piece, and not regular in its results. An improved preparation of archil has been recently introduced into France and England under a patented process. It is called "Solid

French purple," and is sold here in cakes of various sizes, about half an inch thick, just as it is dried from the pulp; they have a purplish hue and an odour of archil. This material is very expensive; at first the patentee charged 200 francs the kilogramme, about seventy shillings a pound; the price has been reduced considerably, but is still very high. It appears to be a greatly improved modification of archil, for, without doubt, colours dyed or printed from it have a fastness far exceeding similar shades from archil, but they are not as fast as madder colours. The patentee or his agents have represented them as being much more stable than is really the case. They suffer both from exposure to the air and from soaping, to an extent which puts them out of the catalogue of fast colours altogether. The shades which can be obtained from this substance upon silk are very fine, and have never been exceeded or equalled for beauty and stability. Upon woollen also it yields good colours, but here the advantage over the ordinary archil is not so marked.

Its application upon calico is a patent right, and, though a very expensive and loose colour, it has been extensively used by some printers. It is dissolved in a mixture of acetic acid and alcohol, then the acetic acid mixed with magnesia to partially neutralise it, and the whole mixed with albumen, printed and steamed. Without albumen the colour is very loose, and, of course, with it it is very expensive. The albumen in this case does not act exactly the same part that it does in the case of ultramarine blue; in that case it was simply a varnish covering the pigment and holding it on to the fibre, but here the albumen becomes coloured itself by the purple dye, and, adhering to the tissue, acts the part of a pigment. The cotton fibres receive but little of the colour, and that little they could not retain well if it was not for the protection of the coating of albumen.

The solid French purple itself is manufactured by precipitating archil with chloride of calcium, and with various processes not to be clearly understood from the specification published.

Kane has separated two substances from manufactured archil, which he considers to be the colouring matter in it; the one is evidently derived from the other, as will be seen upon inspection of the formulæ. The true principles are—

Alpha-orceine, $C_{18}H_{10}NO_8$

Beta-orceine, $C_{18}H_{10}NO_8$

The examination of the original lichens has been carried out in a most complete manner by Kane, Schunck, Dumas, and others. The results of their researches (far too lengthy to give here) have shown that the

purple colouring matters above named are derived, by gradual chemical changes, from colourless substances in the lichens. Orcine, which is itself a derivative, appears to be the radical. The formula of anhydrous orcline, according to Dumas, is $C_{18}H_7O_8$, from which, by the addition of the elements of water and ammonia, the coloured principles are formed. *Orcine* is the name of the colourless radical, and *orcèine* that of the nitrogenised compound which is coloured. There are an immense number of other products of decomposition, which it is not necessary to mention.

Alkanet.—Alkanet is a kind of reedy root, cultivated in some parts of Europe for the sake of its colouring matter. It is very little used in dyeing, and not at all, that I am aware of, in printing. Its colouring matter inclines from red to violet; it is not dissolved by water, but is soluble in oils, turpentine, and spirits, as also, but not so well, in alkalis. Alumina mordants give with it a blue violet, which is sometimes used in dyeing. The colouring matter is extracted by alcohol or spirits of wine, and then mixed with warm water, in which the pieces or threads are winced. The dearth of spirits in this country renders the process too expensive for general use. The peculiar colouring principle contained in it is called *anchusine* or *orcanettine*. Pelletier assigns it the formula $C_{17}H_{16}O_4$.

Aniline Purple.—Under the name of *Harmaline* and *Aniline* a purple liquor was offered for sale in France, in the autumn of 1858, which, properly thickened, gave very agreeable shades of lilac upon calico. Its origin and process of manufacture are not generally known, except in so far that it is obtained from some of the light oils of coal tar, by the action of nitric acid, chloride of lime, and iron filings. A process for making it was patented by Perkins, in England, three or four years ago, but it does not appear to have been offered for general sale until it came from France. Perkins's published plan of making these colours seems very expensive and tedious. The French manufacturers charge very high for this liquor, but are evidently in possession of processes for making it not generally known in this country, and which, in fact, vary for different manufacturers. The method of its application is very simple, but, like the solid French purple, it is very little good on cotton unless combined with albumen. It requires no mordant, but simply to be thickened with albumen, printed, and steamed. It cannot be called a fast colour, as, compared with madder lilac, it neither resists soap nor exposure to air for a length of time, although upon this last score it would not be objectionable, standing tolerably well. The shade it produces, though not so blooming as that from the

French purple, is very fine and desirable, it looks like a fine madder purple. It can be chemically distinguished from all other purples by its power of temporarily resisting the action of strong nitric acid.

ORANGE COLOURING MATTER.

Anotta.—This is a colouring matter obtained by rude processes from certain seeds of an American tree. It usually comes to this country in cakes of small but irregular size, and variable appearance as to colour and hardness. This substance appears to contain two colouring matters, a red and a yellow; but they adhere to one another in most of the dyeing processes, and produce orange colours sometimes red and sometimes more inclined to the yellow or buff side. Anotta does not dissolve well in water, it requires the presence of alkalis; in printing it is dissolved in pearl ash, and mixed with soft soap and other ingredients. It fixes without any mordant on calico, giving buff or chamois shades, which are pretty, but not fast. It is not used in woollen dyeing, or, if at all, extremely little; the alkalinity of the solution is against its application to woollen, even if the shades it produces were desirable, which is not the case, either on the ground of cheapness or stability. It is used more extensively in silk dyeing, for shades of orange, cinnamon, and the like. The silk is prepared by a weak alum steep, and dyed in the solution either cold or nearly so, to avoid the injurious action of the alkali upon the fibre. By passing into a weak acid liquor, after dyeing, the shade is turned redder; acetic acid, lemon juice, or alum, may be used for this purpose. Some cautions are necessary with regard to the use of anotta: it should not be dissolved too hot, nor should too much alkali be used in making the solution; in either case the shade of colour is likely to be much altered. It is to be recommended that for printing the heat should not pass a blood heat, and constant stirring will compensate for higher temperature; for dyeing, where the solutions employed are much weaker, the process may be advantageously performed at natural temperatures.

We find the following analysis of the pulpy part of the seeds of the *bixa orellana*, from which anotta is obtained, it is by John:—

Colouring and resinous matters.....	28.0
Vegetable gluten	26.5
Ligneous matter	20.0
Extractive colouring matter	20.0
Other extractive matters.....	4.0
Odorous and acidulous matter	1.5
	100.0

Its pure colouring principle has been named *bixine*. There appears to be another principle derived from bixine, which is the colour as seen in ordinary anotta, it has been named *bixène*; it is supposed to be derived from bixine by the addition to it of oxygen and the elements of ammonia. Upon this assumption the use of decomposed urine in the manufacture and preparation of anotta is accounted for. A decoction of anotta is remarkable for giving a bluish colour when acted upon by sulphuric acid; pure bixine does not show this reaction. The developed colouring matter or bixène has a faintly acid reaction. Bixine does not appear to have been analysed; its formula is not published.

Bixine.—This name is also given to a purified extract of anotta made in France, and used among dyers. It is in hard cakes, not having much resemblance in smell or appearance to anotta, but possessing all its dyeing powers in a high degree. All anotta colours may be obtained from it with more certainty than from the crude material, but whether cheaper or not I do not know.

GREEN COLOURING MATTER.

It seems extraordinary that, notwithstanding the overwhelming predominance of green in nature, there should not have been until lately any colouring matter known which would of itself yield a green dye. All greens, so far, have been made from mixtures of yellow and blue, and it is probably owing to the facility of procuring all shades of green from such sources that the natural self-colour has not been looked for. About ten years ago samples of green dyed cloth came from China to Europe, which, presenting peculiar appearances, were subjected to examination by the French chemists and they not being able to separate it into blue and yellow, consequently declared that it must be a simple pure green colour, not compounded, as all other greens were, of the two colours. Further inquiries were instituted, and through the agency of the Jesuit missionaries very full information was obtained, and not only samples of the colour itself in various stages, but a considerable number of the young plants from which it was obtained and a large quantity of the seeds were sent to France. It is only within twelve months that any considerable quantity of this green dye has been imported into Europe. It has received the name of green indigo, but I am not aware that it has been used in England up to this time. I had occasion to make a number of experiments upon it from a small sample supplied by a London house

out of the first lot imported. It has been used in Lyons for dyeing silk of an agreeable grass green colour; it is also applicable to calico, but not so well to woollen. It has the singular property of showing the same shade by artificial as by natural light; all other greens being of quite different shade when exposed to artificial light.

An abstract of the history and preparation of this substance, and the result of my inquiries upon it, may be of some interest. It is obtained from the bark and small branches of a shrub called *Lo-Kao*, and is extracted by steeping in water, and apparently through the action of lime. According to the account of Father Hélot it must resemble indigo very considerably in some of its characters. The coarse calico of the Chinese is dyed by dipping in the liquor extracted from the bark and branches, and exposing on the grass to the action of the sun and air; that side of the piece which is uppermost acquires a darker colour than the other. It takes from five to seven dips to obtain the darkest shades. It is quite certain that this is a very cheap process of dyeing, from the fact that the dyed cloths sell at only a small increase upon the price of the undyed ones. The green colouring matter which has been sent to Europe is prepared by a subsequent treatment of these dyed pieces as follows:—The pieces are passed through a large copper of hot water and agitated so as to remove all the loose colour from them; after a sufficient number of pieces have been passed through, so that the water is filled with the green dye which was in excess upon the pieces, fine cotton wool is put into the liquor to attract the green coloured particles; this is washed, and the colouring matter detached by subsequent processes, and dried at a gentle heat. In China it sells for its own weight in silver, but what it is used for is not clear. The price demanded in London in 1858 was ten shillings per ounce. It is very evident that if this green is to be of any use in Europe it will not be from this secondary lake prepared by these tedious processes, but from the original branches and leaves, or at least from some concentrated extract prepared from them after the manner of the indigo process, and not by the intervention of dyeing pieces and taking off the excess of colour from them.

Green colours are obtained from the lake by steeping it in water until it is quite softened, and then warming it with a small proportion of carbonate of soda. The alkali does not seem to bring the green into a perfect solution, but it causes it to gelatinise, and pass into a state of suspension, from which it is not readily deposited. By simply steeping calico in this solution, wringing out and letting remain moist for a few hours, the green becomes fixed as far as it can be fixed. It stands washing in water, but boiling in soap removes it completely. Mordants

are of no avail in fixing it; it is a very fugitive colour on calico. It dyes very far, and though so dear might be employed with advantage in dyeing light goods of a pleasant green colour, which are not expected to stand washing, such as millinery articles, gauzes, and light fabrics. It seems very probable that the first green dyed from the original matter is much faster than that which can be obtained from this product. This question will have an opportunity of being tested, if the seeds and plants sent to France are found to flourish in that climate.

A green colour can be extracted from common meadow grass by hot water, but it is not of any practical utility.

The green colouring matter which pervades all the vegetable world is of a waxy nature, and is called *Chlorophyll*. Whatever its stability may be in its pure state, it is evident, from the change which takes place in the autumn upon leaves and grass, that it is very easily acted upon by the air and sun as mixed with vegetable substances. It exists only in very small quantities in the leaves of plants and trees, and has never been put to practical use.

The foregoing account of colouring matters includes all those which are in regular use in Europe; but, besides the colouring matters mentioned in these last pages, there are several others which are employed in different parts of the world, and which could be also employed here if economical reasons did not interfere. I have compiled a tabular statement of all those which are known to be in use, along with the botanical name of the plant from which each one is derived, the mordant it is used with, and the colours it yields. For some of the names I do not know the English equivalents, and they stand either in the French or Latin. The different colouring matters are classed, as much as possible, in groups of those which yield the same colour:—

COMMON NAME.	BOTANICAL NAME.	MORDANT USED.	COLOUR OBTAINED.
Indigo	Indigofera	None	Blue
Litmus	Lichens various	Alumina	Blue and violet shades
Legwood	Hematoxylon	Copper and alum	Blue
"	Campeachianum	Alumina	Purple and black
"	"	Iron	Black
"	"	Tin	Lilac and purple
Belladonna	Atropia belladonna	?	Blue
Madder	Rubia tinctorum and other Rubiacees	Alumina	Pink and red
"	"	Iron	Purple and black
"	"	Tin	Fugitive red on calico
"	"	Alumina and iron	Chocolate shades
Munjeet	"	Like madder	Like madder
Ouenghoudow	"	"	"
Chayaver	"	"	"
Nona	"	"	"
Hachrout	"	"	"
Brazil wood	Cesalpina echinata	Alumina and tin	Red
"	"	Iron	Browns and blacks
Sapan wood	Cesalpina Brasiliensis	Same as Brazil	As Brazil wood
Peachwood	Cesalpina cressia	Wood	"
Lima wood	Cesalpina pulcherrima	"	"
Santal wood	Pterocarpus santalinus	Alumina and tin	Red
Dragon's blood	Dracæna draco	"	Red
Murier d'Inde	Morinda citrifolia	"	Red
Safflower	Carthamus tinctorius	No mordant	Pink and red
Cochineal	Insect living on Cactus coccinillifer	Alumina	Red and crimson
"	"	Tin	Scarlet
"	"	Iron	Lilac and peach
Kermes	Insect living on Quercus coccifera	Same as cochineal	Same as cochineal
Elecampane	Inula helenium	?	Red and blue
Lady's straw	Gabium verum	?	Red
Camwood	Baphia nitida	Alumina and tin	Red
Peganum seeds	Peganum harmala	Alumina	Red
St. John's wort	Hypericum perforatum	?	Red
Chica	Bignonia chica	Alumina and tin	Red
"	"	Iron	Browns and drabs
Fuchsine, etc.	From aniline	Albumen, or none	Red, pink
Paraguanan bark	?	?	Red

COMMON NAME.	BOTANICAL NAME.	MORDANT USED.	COLOUR OBTAINED.
Murexide	Animal origin	Mercury	Red
"	"	Zinc	Yellow, orange
Weld	<i>Resida luteola</i>	Alumina	Yellow
Fustic	<i>Morus tinctoria</i>	Alumina	Yellow
"	"	Iron	Drabs, olives
Quercitron bark	<i>Quercus tinctoria</i>	Alumina	Yellow
Fustet	<i>Quercus nigra</i>	Alumina	Yellow
Saffron	<i>Crocus sativus</i>	?	Yellow
Rhubarb root	<i>Rheum palmatum</i>	Tin	Orange, yellow
Persian berries	<i>Rhamnus catharticus</i>	Alumina and tin	Yellow
French berries	<i>Rhamnus tinctorius</i>	"	Yellow
Anotta	<i>Bixa orillana</i>	None	Orange
Acacia flowers	<i>Robinia acacia</i>	?	Yellow
Aloes	<i>Aloes succotrina</i>	?	Yellow
Vulneraire	<i>Anthyllis vulneraria</i>	?	Yellow
Gamboge	<i>Cambogia gutta</i>	?	Yellow
Lucywood	<i>Prunus mahaleb</i>	?	Buff
White thorn	<i>Mespilus oxicantha</i>		Yellow
Barberry	<i>Berberis vulgaris</i>		Yellow
Dyer's broom	<i>Erica vulgaris</i>	Alumina	Yellow
Camomile	<i>Athenus tinctoria</i>		Yellow
Centuary	<i>Centaurea jacea</i>		Yellow
Celandine	<i>Chelidonium majus</i>		Yellow
Turmeric	<i>Curcuma longa</i>	?	Yellow
Maple tree	<i>Acer campestre</i>		Yellow, brown
Dyer's broom	<i>Genista tinctoria</i>		Yellow
Nenuphar	<i>Nymphaea alba</i>		Yellow and brown
Walnut	<i>Juglans regia</i>		Brown
Poplar bark	<i>Populus nigra</i>	?	Yellow
Plantain	<i>Plantaneus occident</i>		Brown and black
Wild apple	<i>Pyrus malus</i>		Lemon, yellow
Savoury	<i>Serratula tinctoria</i>		Brown and yellow
Morrel	<i>Solanum nigrum</i>		Violet
Fresillon	<i>Ligustrum vulgare</i>		Violet
Archil	<i>Variola dealbata</i>	Alumina	Red, purple
Cudbear	<i>Lichen rocella</i>	"	"
Litmus	<i>Lichen tartareus</i>	"	"
Alkanet	<i>Anchusa tinctoria</i>	"	Violet
"	<i>Lawsonia inernis</i>	"	Violet
Catechu	<i>Mimosa catechu</i>	Copper, alumina	Brown and drabs
Pomegranate bark		Iron	Greys and drabs
Sumac	<i>Pentondria trygynil</i>	Iron	Drabs and greys
Gall nuts	<i>Quercus var</i>	Iron	Black and greys
Bablah	<i>Mimosa ceneraria</i>	Iron	Drabs, olive
?	<i>Datisca cannabira</i>	?	Yellow
?	<i>Spiræa almaria</i>	?	Yellow
?	<i>Betula alba</i>	?	Yellow
Aniline		Albumen, or none	Violet
Divi divi		Iron	Grey, black

PART SECOND.

PRACTICAL APPLICATIONS OF THE CHEMICAL MATERIALS USED IN BLEACHING, DYEING, AND PRINTING.

CHAPTER XXV.

BLEACHING OF COTTON WOOL AND SILK.

BLEACHING means the whitening of a coloured material, by the removal or destruction of substances which colour it. The term has, however, a more extended meaning as applied to textile materials; and, besides whitening, bleaching is understood as a process which prepares them for dyeing. Whiteness is the only essential point in goods which are not intended to be dyed, and the processes employed are simply directed to the removal of those substances which interfere with the pure white of the material. For dyeing purposes whiteness is not always an essential point: what is essential is the removal of certain substances which exist in the fibre, and are inimical to the entrance of the dye. If light and bright shades are required, it is necessary also that the fabric should be free from the dull grey colour naturally belonging to it; but, for dark and heavy colours this is not necessary. In any kind of dyeing where part of the fabric is intended to remain white, as in dyeing after

printing, both points must be attended to; the cloth must be a good white and free from all foreign matters; because, otherwise, the white parts would become tinged with the dye, and it would not be possible to restore the white to its original brilliancy without at the same time injuring the coloured parts of the design. Therefore, bleaching for printing is the most difficult branch of this art, and requires the greatest care and skill to accomplish it in a satisfactory manner. The means employed for bleaching depend upon the nature of the fibre, and are different for cotton, silk, and wool.

Bleaching of Cotton Fabrics.—Cotton is not bleached in the unspun state, but always as yarn or woven goods. In that state it contains, in addition to the pure white fibrous matter, certain other substances, some of which are natural to it, and others which have been acquired in the process of its manufacture. The best quality of cotton is nearly white to begin with; inferior qualities are more or less coloured with resinous brown substances, which they derive from the plant. In the course of gathering, packing, storing, and manufacturing, dirt accumulates upon it, and a piece of grey calico is likely to contain a great many different matters, among which may be enumerated animal exudations of perspiration; dust, entangled in the fibres, which may be of a chemically active nature or not; greasy matters, from the hands and machinery in spinning; metallic particles, from the metals with which the cotton is kept in contact in manufacturing operations; a kind of metallic soap is formed, under the same circumstances, from the fatty matters and oxidised metals; also various stiffening or dressing materials, depending for quantity and quality upon the kind of cloth and the custom of the manufacture; lime and other earths, in combination with size, flour, and starch, are most usually met with, and exist in greater quantity in heavy goods than in calico, especially in cotton velvets, cords, etc., which are required to be stiff for the purposes of the manufacturing operations which precede dyeing. It is the removal of the natural brown colour of the fibre, and these added impurities, which constitutes bleaching.

Singeing or Firing.—With plain goods the first step is to singe off the loose downy threads. This is not a chemical operation; and though the heat is very high, its duration is so short as not to produce any notable chemical change either in the fibre itself or in the substances contained in it. But, judging from the unequal colouring of a fired piece, it might be thought that the heat had acted upon some parts more than others. This is no doubt the case. Owing to the inequality of contact at various times the charring is undoubtedly deeper in some

places than others, but it is always very slight and just on the surface, never extending to the thread, and from the decomposed nature of the charred material it separates mechanically in the subsequent bleaching operations.

Steeping or Wetting Out.—Grey cloth does not absorb water equally and rapidly, and serious irregularities would result if it were at once plunged into the bleaching liquors or kiers. To moisten it thoroughly, and to soften the pasty matters in it, it is steeped in a pit of cold water for several hours; in the case of very heavy goods, they have to be wetted out with boiling water, in a peculiar apparatus, to ensure the thorough penetration of the liquid. In warm weather the pit is liable to enter into a state of fermentation, and to become sour. I am not aware that this does any injury, but it cannot do good, and as a rule pieces should not be allowed to remain until fermentation sets in. After steeping the pieces are either washed or go at once to the kiers. The remaining treatments are as follows, for printing cloth, unless otherwise mentioned.

Bowking or Liming.—The cloth is placed in kiers, with lime well slacked and mixed with water to the state of a weak milk of lime. Care must be taken that the cloth is not too tightly packed in the kier, and that sufficient room is left for a circulation of the lime and water by the throw-up pipe and bonnet. The kier should be covered up close, for it is advisable to keep the air from the cloth while being boiled with lime, for reasons which have been mentioned. If the cloth be always kept covered with liquor it will suffice, but this loses heat by the escape of steam, and weakens the action of the lime. From eight to sixteen hours, according to the size of the kier and quantity of cloth, will be required for the lime to operate. The cloth looks darker coloured after the lime treatment than before, having become brown and rusty looking. It is washed at once, but before coming out of the kier the spent lime liquor should be run off, and the pieces cooled with clear water, as it is dangerous to leave the pieces in contact with lime and air. The action of the lime in bleaching is simply a preparatory one, it prepares the way for the soda ash, softening the matters to be removed; but it actually removes very little more than a similar boiling in hot water would. Its chief use is in operating upon the resinous and fatty matters contained on the cloth. All greases and oils are compounds of fatty acids with a certain neutral substance, glycerine. In making soap, the strong alkali splits up the oil into the fatty acid with which it combines, and the glycerine which dissolves in the water. The lime acts just in the same manner upon the greasy substances in the cloth; it splits them up into

acids which the lime fixes, because they form insoluble compounds with it, called lime soaps, having the same chemical constitution as regular soaps, but, unlike them, not soluble in water, and so remain fixed upon the cloth where they were formed. From this it is clear that the lime does not remove the fatty substances, it only changes them into such a state as makes them easy of removal by subsequent operations. What is said concerning fatty substances may be considered as applicable also to resinous substances. Nearly all the dressing material is removed by the lime treatment.

Souring after Liming.—The passage of the pieces through sours takes out any lime that may have become fixed upon the cloth, either chemically or mechanically. It decomposes the lime soaps by taking the lime from the fatty matter, the fatty matter yet adhering to the cloth but in an altered or acidified state, in which it is easily acted upon and dissolved by soda ash. The acid also removes any metallic oxides, as iron rust, which may be upon the cloth, and generally loosens the colouring matter which the lime at first seems rather to have fastened than the contrary.

Bowking in Soda Ash and Resin Soap.—After washing out of the sours the cloth is next entered into a kier with soda ash and resin soap, and subjected to boiling heat for several hours. This alkaline treatment removes the fatty and resinous matters and also everything else which can be removed by alkali, which, with the previous and subsequent acid treatments, includes all the usual substances found in good cotton. The application of resin is a great improvement; it ensures a more perfect solution of the fatty and resinous substances, in accordance with a rule that like dissolves like, and is a quite safe and harmless addition when well made. Soap was used by the older bleachers, but it was neither so active nor so cheap as resin. The efficacy of soda ash to remove grease spots is greatly assisted by the liming; it has not much power of itself to take out grease, for under more advantageous circumstances than can be employed in bleaching, the carbonate of soda cannot be made to combine in a perfect manner with fatty matters; but when these fats have once been broken up by a powerful caustic alkali they become easily acted upon by the carbonated alkalies, and it has been proved that even without the souring between the liming and ash bowking, carbonate of soda can act upon the lime soap so as to remove all the fatty matter from it, leaving in its place the carbonic acid which it had given up for the fatty acid. Resin soap is useful in giving stability to this new soap formed from the soda and natural grease of the cotton. It is well known that soap in dilute solutions is liable to decompositions by which an acid insoluble soap is produced, and this even in pure water; the more so in

contact with saline matters, and the less so as the quantity of soap is greater in ratio to the quantity of liquid holding it in solution. The resin soap may thus be conceived as adding itself to the soap produced and insuring it from another decomposition, at the same time that it facilitates the formation of the soap itself, and helps to scour the cloth from those indefinite substances which in the aggregate are called dirt.

Chloride of Lime or Bleaching Liquor Steep.—When all the foreign substances have been removed from the cotton by the treatment detailed above, it is still of a dull colour, short of that snowy whiteness which is desirable in trade. Repeated treatments with alkali and acid could remove this last trace of colour, but such a process would be tedious and expensive. The property of chlorine to destroy colours is brought into requisition. The solution of bleaching powder employed is very weak ; the pieces are passed through it and squeezed out so as not to retain too much. They are left some time for the action to commence. The smell of chlorine about the pieces shows that the chloride of lime is operating ; it is probably rendered active by the carbonic acid of the air exerting some affinity for the lime, but to a greater extent by the cloth itself, which has a slight decomposing power on all salts. The action is not complete without the help of sours, through which the pieces are passed ; the sulphuric acid takes the lime, sets free the chlorine in the heart of the fibre, where it acts upon the remains of the colouring matter, destroying it as such and changing it into some colourless compound, which is probably dissolved by the acid liquor, and finally removed from the cloth by the last washing. It is important that not a trace of acid or lime salt should be left in the fabric ; to remove these, and with a view to soften the cloth, the pieces are in some places run through hot steam water before going to the drying machines.

The finishing of bleached goods for the market is mainly a mechanical operation. A good deal of thickening is sometimes introduced to give fulness and weight to the cloth. This may be looked upon as a kind of adulteration, as it is meant to deceive the purchaser. A little blue is added either to the last water the pieces pass through or to the finishing material. A good blue liquor is obtained by dissolving that kind of Prussian blue sold under the name of Chinese blue, in oxalic acid and water, but a kind of ultramarine blue gives better results, the Prussian blue being rather too transparent and deficient in bloom. The blue has an optical effect in correcting the orange-yellow reflection which even well bleached pieces possess ; according to the laws of colour this blue, added to the red and yellow which give the buff or chamois shade, constitutes a mixture which is white, but in reality it is an overpowering

of the yellowish cast by the blue, which is always used in some slight excess, as a bluish tinge is required in most markets.

It is customary to work the lime and ash kiers at ordinary atmospheric pressure, letting the steam blow freely off. A patent was taken out some years ago by Messrs. Pendlebury and Barlow, for working the kiers under considerable pressure, as high as 50lbs to the square inch. The process is becoming generally adopted, and I am informed it effects a considerable saving in time. I have seen and tested cloth bleached by this method, and have found it at least equal to the best regular madder bleach.

Bleaching for indigo dyeing can be done much more simply and expeditiously than for madder dyeing. All that is required is, as the bleachers say, to bottom the cloth well, that is, to remove all those foreign matters which interfere with the easy entrance of the dye; whiteness is not necessary. The same remarks apply to several other cases of dyeing; it is only a waste of time and material to bleach white that which is intended to be dyed with dark colours all over its surface.

Accidents in Bleaching.—Remarks upon the action of lime, rosin, and acids, upon cotton, have been made in previous parts of this work, and need not be repeated here. In dyeing, there are occasional blemishes, which are attributed to defective bleaching. They mostly assume the form of light spots of various shades and extents, sometimes extending in long lines down the length of the piece. 'Colours dyed or raised cold, show this species of defect the most strongly. It is not certain what it is owing to, but it seems most probable that it is some species of fatty matter, perhaps a lime soap, not properly decomposed by the acid. Pieces which are suspected of being in this state can be tested by passing them rapidly through cold water, the greasy parts do not become wetted for a moment or two, and it is easy for a sharp eye to detect the outline, shape, and extent of those parts, which, whatever they may be attributable to, will infallibly cause irregularities in such styles as those alluded to. As to their being simple grease stains, I see reason to doubt it; it is possible, that long age of a grey piece would put the fatty matters into some state not so easily removable as when fresh, as if, for example, the oil was one which dried up into a varnish. But the regular bleaching treatment is able to move very old grease spots purposely made, as I have frequently tested. I have not been able to make any grease spots which were not completely removed by a good bleaching, although it is quite possible such stains might be produced. These kind of accidents are always difficult, and frequently impossible, to explain: either the men in charge of the operations are not candid

enough to say where the goods have been neglected, or else they are not observant enough, and do not know. But the acutest observer is repeatedly baffled in endeavouring to discover where the mistake is made; but, undoubtedly, there is neglect somewhere, for these things can be avoided. Tender pieces are produced from several sources, but may be mostly attributed to the chloride of lime and sours. It is a fact, that some kind of cloth goes rotten under treatment which does not affect other qualities; and I have known cases where the tendering of the cloth could only be attributed to the lime bowk, and in other cases to the ashing. Some lime contains unusual quantities of the alkalies, potash, and soda; it is possible these may act injuriously, by being converted into caustic. Some soda ash contains caustic soda, which is liable to injure weak cotton. Of the two acids—sulphuric and muriatic—the latter is the one which will soonest injure the cloth, and requires the greatest care in its application: it dries up quicker at the edges of the pieces, and becoming stronger, rots the fabric. The bleaching croft should be so situated, that the pieces which have been chemicked, as well as those which have been soured, shall be, while remaining in contact with the chemick and sours, protected from currents of air and strong direct light. A low roof, and few windows, with no through drafts, is the best kind of building for the pieces while at rest.

Bleaching of Woollen Goods—Wool, as gathered from the sheep, contains a large proportion of a greasy or soapy matter, which is mostly removed before it is spun. This natural protecting substance, no doubt intended to throw the water off the fleece, or to prevent its absorbing too much, is easily removed by steeping in warm water and stale urine. As the woollen goods come to the dyer or printer they contain nothing which requires removal beyond the greasy matters left in from the first treatment, or which have been added in the spinning. Wool is never dyed with the idea of preserving any part of it white; its affinity for colours is so great that it takes them without mordant, and whites could not be kept clear in the dyeing. Its bleaching does not present much difficulty, nor require so many processes as calico, nor would it resist the same agents. The contact of lime, ash, and bleaching powder would destroy the fibre of the wool almost before they could destroy the colouring matter. Soap and very weak alkalies are all that are used in the preliminary part of woollen bleaching, and, instead of chlorine, the gas from burning sulphur is used to give it the final whitening. The alkalies must be used very cautiously in contact with wool, as even soap with long and violent boiling will injure it in a remarkable manner.

Crystallised carbonate of soda is the best form in which the alkali can be applied, and a boiling heat should be avoided, because unnecessary to accomplish the object, and, though saving a little time, running a great risk. The sulphuring is given while the goods are moist; the old plan consisted in hanging them in a stove and burning sulphur in vessels, and letting them absorb it; a new plan, the patent of Mr. J. Thom, consists in passing the goods through a box filled with sulphurous gas, produced by burning sulphur in a small furnace connected with it. It has the advantage of being continuous, and permitting inspection throughout the whole process. The sulphuring gives a brilliancy and whiteness to the cloth which it does not otherwise possess, but it is rather injured for receiving colours. Woollen goods which have to be dyed full or dark shades should not be sulphured, but those which have to be dyed light bright colours, or which are meant for printing, must have the ground white, and sulphuring is indispensable.

Bleaching of Silk.—Native silk is either white or yellow, the greater bulk being yellow. The colouring matter is of a waxy nature, and the oldest process of removing it, that of boiling with soap, is the only one which can be advantageously employed at this time. Raw silk loses about one-fourth of its weight by boiling with soap, but only a very small portion of this is actual colouring matter, the great bulk being a kind of gummy, waxy substance, which, though coming off along with the colouring matter, must be distinguished from it. Soap of the best quality only should be used, and alkalies carefully avoided; long boiling with soap will injure the silk considerably both in appearance and strength. Sulphuring can be used, as with woollen, to give the finishing degree of whiteness to it. The loss of twenty-five per cent in weight, upon so valuable a substance as silk, turned the attention of many parties, some years ago, to the devising of processes for removing the colouring matter without taking away the gummy or waxy substance which constitutes so large a portion of the loss. The idea could only be good for selling the silk as raw silk, because it does not appear that silk can be dyed with any safety or certainty unless the whole of the gummy or waxy matter be removed. And the dyers of silk know well enough how to restore something more than twenty-five per cent to the weight of the silk they receive to dye; since it is a point with the silk dealers to ignore the fact of the loss of weight in bleaching and dyeing, and to require not only the same but a greater weight back from the dyer than he received. It is stated that by steeping the cocoons in spirits of wine, mixed with a small quantity of muriatic acid, the colour can be removed,

nd white silk obtained, at a loss in weight not greater than one in forty. The expense of the alcohol, and the little utility of the process, prevented its ever being carried out in a practical manner. The Chinese are stated to have some practical process for making yellow silk white without the use of soap or great loss in weight, but we have no clear information upon the matter.

CHAPTER XXVI.

MORDANTS.

A MORDANT is a substance which can exert an affinity for the fibrous material to which it is applied, and which possesses at the same time an attraction for colouring matters. It is necessary that it should possess these double properties, or it cannot be considered as a mordant. There are substances which combine with fibrous materials without shewing any affinity for colours, and there are others which have an affinity for colours but which cannot contract any adhesion to the fibre. Neither of these can be called mordants. Mordants are not very numerous, and may be divided into mordants proper and mordants of a dubious nature; the first class consisting of those metallic salts whose oxides seem to effect an intimate chemical union with the fibre and colouring matter, and the second consisting of a number of substances which, possessing some affinities for colouring matter, do not appear to combine with the cloth in a chemical but rather to adhere in a mechanical manner. Belonging to the first are the mineral mordants, salts of iron, zinc, alumina, tin, and copper; to the second belong vegetable and animal matters, as galls, oils, albumen, caseine, and two or three others similar in nature. In wool, silk, and other animal fabrics, there naturally exists an affinity for colouring matters, but not to an extent sufficient to yield general good results.

From the above definition of a mordant, it is evident that it is an intermediary agent, uniting two substances which of themselves have no special affinity. Its powers extend on both sides, and must be equally effective on each; on the one to hold firmly to the cloth, on the other to retain the colouring matter in a close state of combination. There are very few colours which can combine with either vegetable or

animal tissues without the aid of a mordant, and, of several which can do so, the majority are much improved, both in brilliancy and fastness, by the presence of a mordant. The colouring matters of madder, logwood, fustic, etc., are only able to give a feeble stain to unmordanted calico, but, by the assistance of mordants, they communicate fast, full, and brilliant colours; on woollen, also, though several of the colouring matters can give a shade to the cloth, without a mordant it is poor and feeble in most cases, short of lustre, and possessing a very inferior degree of stability. On calico there are a few colouring matters whose peculiar natures allow them to contract an adhesion to the cloth without any mordant, and it cannot be said that the presence of a mordant adds in any way to the depth or stability of the colours which they can produce. These colouring matters are indigo, safflower, and anotta. On woollen the number may be extended to a few more, as picric acid, archil, and aniline. With the exception of indigo, which enjoys peculiar properties, unlike any other colouring matter, all these are loose, unstable colours. They cannot be combined with mordants under any of the usual conditions of such combinations, and are obliged to stand alone.

There are certain conditions necessary to a mordant which should be always borne in mind; unless they are fulfilled the mordanting will altogether fail or be deficient to a greater or less degree. Solubility is the first essential in a mordant; unless the metallic oxide, which is to act as a mordant, can penetrate into the very heart of the fibres it will not be able to resist washings, and it can only find such entrance by being in a state of clear solution. A capability of becoming insoluble is the second essential in a mordant. It is apparent that if the solution of a mordant could carry it into the fibre, the same solubility would carry it back again, unless means were taken to fix it permanently upon the spot to which it had penetrated. This condition of becoming insoluble is effected in a variety of ways. The metallic oxide is combined with a volatile acid, like the acetic, which flies off and leaves it insoluble in the fibre;—this is the most common and generally employed method;—or it is combined with any other non-volatile acid, and methods taken to remove the acid by chemical means, such as passing in alkaline baths, exposing to vapour of ammonia, and the like; or, as in the case of nitrate of iron, a salt is chosen which holds one part of its oxide in a comparatively loose state, and, when diluted with water, allows the feeble affinity of the fibre to take it from the acid. This is the case also with alum, when a portion of the acid has been removed by the addition of alkaline salts. The vegetable and animal mordants are different in their method of adhering to the fibre. Oil, as used in Turkey red dyeing,

undergoes a change by exposure to the air, which renders it insoluble and irremovable by ordinary agents. Albumen and similar substances possess a mechanical affinity for the cloth; they are applied in the soluble state, and become insoluble by heat, or some other agent, which coagulates them; they embrace the fabric in a reticulation of fibres, and may be considered rather as holding to the surface than as retained in the interior of the fibre. This leads to the question, which may be naturally asked, what is the nature of the combination which takes place between the mordant and the fibre? Unfortunately there cannot be any direct positive answer given to this question; it is involved in doubt and controversy, and the evidence on the various views is so inconclusive that no satisfactory result has been arrived at. The insoluble particles of the mordant may be retained in a simply mechanical manner by the fibre, which is supposed to be hollow, and to act the part of a trap. The fibres may be porous, and the acid solutions, penetrating the pores, leave their oxides in contact with the walls of the pores, from which they cannot escape, either by reason of the narrowness of the pores or some supposed angularity of the metallic oxides. The mordants may form a chemical combination with the matter of the fibre, and so hold on to each other until separated by more powerful chemical agents, or destruction by time; or the fibre may possess some active power of adhesion on its exterior walls, for metallic oxides, and they may be held together by virtue of the power of contact. All these theories are held, and the evidences which can be drawn from chemical or microscopical observations do not actually tell more on one side than on the other. In the absence of any satisfactory scientific account, we may take the practical supposition that the particles of mordants are held by the fibres in a state of chemical freedom, capable of exerting all their affinities, and drawing to themselves those substances for which they have an attraction.—(See further upon this matter, Chapter XXIX., upon "The Fixation of Colouring Matters.")

The affinity which the mordants have for the colouring matters is undoubtedly of a chemical nature; a given quantity or strength of mordant can combine with only a certain amount of colouring matter to produce a certain shade, and, as is the case in most chemical combinations, the colour of the resulting compound bears no necessary resemblance to that of the constituents. The shades of colour which any dyewood can give differ for each mordant, and for various strengths of the same mordant; the same colouring matter yielding shades which appear quite opposite in their nature, as, for example, madder, which with weak alumina mordants gives pink; with strong, red; with weak

ron mordants, lilac or violet; and with strong, black colours; while a mixture of iron and alumina mordants yields various shades of chocolates. And these colours are undoubtedly derived or derivable from one single colouring matter. The power of the mordant is therefore very great in influencing the shade.

A given mordant has not the same properties upon all kinds of fibre. The tin mordant, so extensively employed in woollen dyeing, and yielding fast colours, is a very feeble mordant on cotton, and never gives colours comparable for fastness with those of alumina or iron. On the contrary, iron mordants are very difficult to employ on woollen, for reasons which have been previously stated.

A mordant may be applied to a cloth in three ways, with regard to the colouring matter. (1) It may be applied before it; this is the usual case in calico printing, for dyed goods, and frequently in piece dyeing. (2) It may be applied after the colouring matter; this is perhaps the most usual case in piece dyeing, where the pieces are first passed through the extract of the colouring matter and then through the metallic mordant; or (3) it may be applied at the same time as the colouring matter; this is the case with many colours in dyeing, and with all steam and spirit colours in calico printing. The first case, viz., that of applying the mordant before the colouring matter, is a necessity in printing designs upon the fabric to be dyed; it is necessary also that it should be fixed upon the cloth in a very perfect manner before going into the dye; because a design requires that there should be at least two shades of colour, one of which may be the white of the cloth; and it is easily seen that if the mordant were loose, or floating about in the dye beck, it would attach itself indiscriminately to all parts, and destroy the design. This fixing of the mordant necessitates several processes unknown in piece dyeing. The second case, that of applying the colouring matter before the mordant, can only be used in self-coloured fabrics, and has arisen from motives of convenience and economy. It usually happens that the mordant is much cheaper than the colouring matter in regard to the quantities which have to be used, and the colouring matter can be more completely used up and less wasted by employing an excess of mordant than in the contrary case. The method of using the mordant and colouring matter together is one of limited application, because in the generality of cases insoluble lakes are formed which are not well adapted for giving good and fast colours, but in several cases of dyeing such a mixture is used. In calico printing it is possible to use the colouring matter in a concentrated state, and in combination with acids and other matters, which keep it and the mordant in a state of solution,

for a time at least, until the affinities of the cloth come into play, assisted also by artificial means, as steaming, passing in alkalies, and the like, which cause the formation of an insoluble compound, the mordant and the colouring principle adhering to the cloth.

Alumina Mordants.—Alum is the oldest and most used of all the mordants; it was formerly employed alone, but later it was found that certain substances greatly facilitated its action, such as tartar, soda ashes, and potashes. Chemical science has shown that these substances are useful as neutralising a portion of the acid in the alum, by which is held upon the aluminous base, which constitutes the mordant, is slackened, and the fibre enabled to abstract more easily the portion of alumina it requires. If a certain portion of alkali be added to alum, and the mixture well stirred up, the liquor remains clear; if much be added, all the alumina is precipitated as a pulp, and the clear liquor has no more mordanting power than pure water. It is plain, then, that this gelatinous precipitate is the mordant; but in this state it cannot obtain admittance to the fibres or pores of the cloth—it is necessary that it should be dissolved. It may be dissolved in either acids or alkalies, and in either state it is capable of penetrating the fibre, but cannot unite with it unless the solvent acid or alkali be removed or weakened in some way. The common alumina mordant of the calico printers, called *red liquor*, is an impure compound of alumina with acetic acid. It is made by mixing together alum, dissolved in water, and acetate of lime or lead: the lead or lime change places with the alumina, and there is left the acetate of alumina. Acetic acid has only a feeble affinity for alumina—it is a volatile acid, and when cloth is steeped in it and dried it evaporates, leaving the alumina. If common alum be applied to cloth in the same way not a particle of alumina will be found to have adhered to it, because the acid with which it is combined in alum is a strong and non-volatile acid, and does not leave the alumina unless it has some stronger base to go to. Calico boiled with alum does not acquire any mordant. Woollen, having stronger affinities than cotton, does take a little alumina from alum, but its quantity is insignificant. If acetate of lead be mixed with alum and hot water, and cotton cloth then passed in it, it takes up alumina in sufficient quantity to dye with. The reason is that the sulphuric acid, which held the alumina previously, has gone to the lead, and the acetic acid being feeble does not offer any strong opposition to the cloth taking up alumina from the liquor. In mordanting woollen cloth, cream of tartar, that is, bi-tartrate of potash, is used to mix with the alum, and here a similar decomposition takes place, the sulphuric acid goes to the potash, leaving the tartaric acid to the alumina, from

which the wool can take it tolerably easily. The acetate of alumina would not answer so well for woollen as the tartrate, perhaps because it would give up its alumina too readily, and the mordanting would be of a merely superficial character, without sinking deeply into the fibre.

The alkaline solution of alumina, or aluminate of potash, is not much used; it is not applicable to silk or woollen goods on account of the destructive action of the alkali upon these fabrics, and its application upon cotton is attended with numerous difficulties. The method of its manufacture has been described under alumina. It is applied in the production of madder pinks, for which it appears to possess some advantages over the common red liquor. Its alumina does not combine with the fibre until the potash is taken away by some chemical means; as before stated, this is usually done by passing the goods through solution of muriate of ammonia, or some metallic salt.

The alumina has been spoken of as the mordant; it is quite certain that this is the case in some instances, but it is probable also that in the usual case of red liquor mordants it is not the pure oxide of aluminium that forms the mordant, but some compound of it with acid, either sulphuric or acetic. If this supposition be correct, it will be a very basic salt, that is, a salt which will contain many atoms of alumina to a single atom of either of the acids. It is known that basic sulphates can constitute good mordants, and it seems likely that this saline state of the alumina is, on the whole, more favourable to its combination with colours than the pure alumina. Pure alumina, as deposited from the aluminate of potash, is subject to a variety of accidents, from which the red liquor mordants are free. I believe this may be attributed to its state of purity, and that it would be more stable and regular if it were in some saline state.

The *Nitrate of Alumina* is not used, that I am aware of, except in topical colours. It possesses no advantage as a mordant over the common alum, but in some cases its nitric acid acts beneficially as an oxidising agent.

Oxalate of Alumina has been proposed as a mordant, but it does not part with its alumina readily, except under the influence of steam and colouring matters, and is of very limited use.

IRON MORDANTS.

The oldest form of the iron mordant, and that in which it is still extensively employed, is the sulphate of iron or copperas. The chief

iron mordant used by calico printers is the impure acetate of iron, made from pyroligneous acid, and called iron liquor, or black liquor. The nitrate of iron is also used largely, both by printers and dyers. On the continent, but not in this country, as far as I am aware, iron alum is used to some extent; it is a compound of sulphate of potash with the per-sulphate of iron.

Sulphate of Iron.—Cloth cannot abstract much iron from this salt, because of the strength of the acid with which the metal is combined. If a comparatively small quantity of green copperas be dissolved in a large quantity of water, and cotton cloth winced through it, the cloth will take up iron in an uniform manner, but only to a limited extent, and this is owing not so much to any strong affinity of the cotton, which removes the iron, as to certain accidental circumstances, which weaken or destroy the affinity of the iron and acid. These are, the presence of lime in the water, which neutralises the acid; the presence of oxygen, which raises the iron to a higher state of oxidation, in which it is more indifferent to the acid; and a certain power of decomposition which large bodies of water exert upon most metallic salts. Cloth dipped in strong clear solution of copperas does not take any iron from it. In dyeing shades with copperas, the most usual practice is to apply it after the cloth has been impregnated with the colouring matter—the logwood, fustic, sumac, etc.—it forms then a combination with the colouring matter in the fibres of the cloth, and the cloth, thus assisted by the decomposing power of the colouring matter, can draw to itself a sufficient quantity of the iron mordant. The sulphate of iron is also used mixed up with the colouring matter, but not frequently. In this case it may be supposed that the iron and colouring matter do not form a very intimate combination with each other until the presence of the cloth adds a third element, and gives them, as it were, a ground upon which to unite. Sulphate of iron is sometimes used to darken shades, by simply passing them through it. But it is preferred, as a general thing, to use it in combination with galls or sumac as a saddener of shades. There are cases in printers' dyed goods where it is necessary to have a darker shade; as, for example, when a lot of garancines are much redder than they should be, these can be darkened by a wince in weak copperas. Some precautions are necessary; if the copperas, say at the rate of one pound to a hundred gallons of water, be mixed up in the pit, the water will be turbid, and if the pieces are winced in it they will be darkened, but the whites will be stained a light buff, which cannot be removed. No moderate addition of acid to the turbid liquor will clear it, but if an ounce or two of strong vitriol had been added, previous

to the addition of the copperas, the turbidity would not have taken place, and the pieces might have been darkened without any injury to the whites. Wherever copperas is used as a mordant, and dark shades are to be obtained, many repeated dippings and passings in the liquors are necessary, because, as will be understood from what has been said, the metal and the acid have too great an affinity for one another to allow the cloth to abstract much of the former at one time.

Acetate of Iron.—Fibrous substances can be easily impregnated with oxide of iron by means of the acetate, for reasons which depend upon the peculiar constitution of iron salts, and the different affinity possessed by the two oxides for acids. The acetate of the protoxide of iron is in itself a salt of tolerable stability, but when acted upon by the air it absorbs oxygen, and its constitution is completely changed. Some acetate of peroxide of iron is formed, which is a very unstable salt, losing its acid almost as soon as formed, and leaving the oxide in an insoluble state; a greater portion of the acetate is decomposed by the absorption of oxygen to a less degree than is required to form the peroxide, or the portion which is oxidised into peroxide may react upon the remainder, in some manner not yet clearly understood, and set the acetic acid at liberty, which, leaving the cloth, permits the fixation of the iron. This is what ultimately takes place, if sufficient time be allowed. In the case of using the acetate simply in the wet state, it imparts its base more freely to the cloth than copperas, simply on account of the weakness of its acid compared with the acid of the copperas. The iron liquor, as made by the manufacturers in Lancashire, contains a large quantity of tarry substance, to which the dark colour of the solution is due, and to which also some of its chemical properties are attributable. A pure kind of iron liquor may be made from sugar of lead and copperas, but it does not answer so well as the less pure kind made from wood acid and old iron, or even that made from the rough pyrolignite of lime and copperas. It seems proved that the utility of this tarry matter consists in its preventing or hindering the too great oxidation of the iron. Iron at its maximum of oxidation is not a good mordant, that is, it does not combine well with colouring principles, and the compounds which it does form are subject to a change or decomposition, under which the excess of oxygen, from the iron oxide, goes to the colouring matter, to alter and usually to injure its shade. The combinations of colouring principles with iron are usually with the iron in the state of the protoxide, and to form this combination the iron must be in that state, or chiefly so, upon the cloth; if it is not in that state it is usually brought to it by the deoxidising

powers of the colouring principles, if they have that power, if not the resulting colour is usually poor and unstable.

The acetate of iron is largely used in calico printing for obtaining blacks and all shades of purple and lilacs, and in mixture with the acetate of alumina for chocolates. It is, of course, essential that it should be quite insoluble, or fixed, before it goes into the dye liquor; because, if otherwise, the whites would be coloured, as is more fully explained in the section on dunging; but if it should so happen that the iron is quite peroxidised, as can be effected by bichrome and bleaching powder, no good colours can be obtained; in fact, hardly any kind of colour will be attracted by the iron. But if the iron be submitted to some reducing agent, its power of absorbing colours is partially restored to it. This proves the fact of the lower oxide of iron being the mordant, and shows why the purer kind of acetate of iron does not answer very well, not having any organic matters to prevent its passing into the maximum state of oxidisation. Several substances are added to iron liquor for calico printing, with a view of hastening the fixing of the mordant, causing it to fix more uniformly, or to give better shades. Amongst the materials added may be mentioned arsenic, lime water, sulphate of copper, sal ammoniac, acetate of copper, etc. Without denying that these additions may be found useful in some places, and under some circumstances, I can say that they are not only not useful, but really injurious, as added to the usual quality of iron liquor produced in Lancashire. No addition of any kind improves its quality, and such substances as may be used to facilitate its fixing are employed at a continual risk of giving bad results.

Nitrate of Iron.—Nitrate of iron is largely used as a mordant, both by dyers and printers. Its chemical composition is of a very complicated nature, being a mixture of perhaps several nitrates of iron, some neutral, and some with an excess of base. When diluted with much water, and especially in contact with fibrous substances, a change in the composition of these salts takes place; the basic salts part with a portion of the oxide of iron they contain, and assume the composition of acid salts. In the presence of cloth, by which this decomposition is largely induced, the liberated oxide of iron is, of course, deposited upon the fibre. In this case, as in the case of sulphate of iron, the precipitation of mordant upon the cloth soon ceases, on account of the growing acidity of the liquor, and the consequently more powerful retention of the oxide by the acid. To produce deep and well-filled shades from the nitrate of iron mordant, requires reiterated passages into the mordant and colouring matter. In comparison with sulphate of iron it is a much stronger

mordant, giving up more iron to the cloth; the iron being in a state of the highest oxidation. It is used for dyeing blues, with prussiate of potash; and for blacks, upon silk and woollen, which are not of a very fast kind. In calico printing, the nitrate of iron is only employed as a mordant along with the colouring matter in steam and spirit colours. It is used also in woollen printing and dyeing. If used strong, in calico printing, it injures the fabric from two causes,—first, the acidity of the compound or acid liberated during the process of fixing; and secondly, owing to a disorganising effect which the peroxide of iron itself has upon cotton fabrics. The same colour which would be good upon woollen or delaine would be too strong; and quite destroy the soundness of cotton cloth.

Some of the phosphates and arseniates of iron are soluble in ammonia, and capable of being employed as mordants. I have tried them, and came to the conclusion that they were of no practical utility, although highly spoken of by some French writers. The ammoniacal solution of pyro-phosphate of iron yields, with madder, some agreeable shades, of a greyish lilac colour.

Tin Mordants.—The affinity of the oxides of tin for colouring matters, and for textile fibres, is not inferior to that of any other oxide, and in some respects seems superior to all others. There are, as already stated, two distinct oxides of tin, the protoxide and the peroxide, the latter containing twice as much oxygen as the former; and although the protosalts are generally applied as mordants—as the crystals of tin and common liquid muriate of tin—it seems probable that it is as the higher oxide that it acts eventually as the bond between the colouring matter and fibre.

Tin is used both dissolved in acids and alkalies. In acids it constitutes the dyers' spirits,—crystals of tin, muriate of tin, double muriate of tin, bi-chloride of tin, and oxymuriate of tin. An alkaline solution is sometimes made by printers and dyers, by simply mixing one of the salts of tin with caustic soda, adding the latter until the pulp at first formed dissolves; in this way the lower or higher oxide may be equally well dissolved. Stannate of soda is a commercial combination of the peroxide of tin with soda. The term stannate is derived from the Latin name of tin, viz., stannum; and the oxide, acting the part of an acid in this case, is called stannic acid.

Each of the oxides of tin has a general affinity for all the varieties of fibre, and combines equally well with cotton, wool, and silk; but the combinations are not of the same permanency in each case. They are more permanent on wool than on silk and cotton, and more powerful on

the former than the latter. Tin mordants, upon cotton, give a class of colours which are called "spirit colours," from the old name for solutions of tin; they are easily made, look very well, but are not fast. Tin, upon cotton, should be employed rather as an useful auxiliary than as a sole mordant; it serves to brighten colours, but it ought not to be depended upon for giving permanent colours. In dyeing, various salts of tin are largely used for producing fancy shades upon cotton. The method of application usually consists in mixing the solution of tin with the colouring matter, and running the piece through the mixture until it has taken up as much as is required. Colours so produced do not possess much stability. A better method would be to prepare the cloth first with tin, by means of the stannate of soda, and then run it through the mixture of tin solution and dyewood. The basis of tin being more intimately connected with the fibre in this case, the adhesion of the coloured compound is the more perfect.

All calicoes and delaines for printing in steam colours are thus prepared with a basis of tin oxide, not invariably derived from the stannate, but also from the oxymuriate, or mixtures of two or more of the different solutions. The stannate is usually preferred, as giving more regular results, and being more easily managed. It is applied as follows:—A clear solution of the salts, frequently called preparing salts, is made of the right strength, which may vary according to the requirements of the situation, from 10° Twaddle to 40° Twaddle; a strength of 16° Twaddle, of a good quality of salts, will be suitable for most of the usual styles of steam colours. The calico or delaine is padded in this once or twice and left to stand a short time. It is then passed in vitriol sours at from 2° to 4° Twaddle, care being taken that there is always an excess of sours present. If they become neutralised by the alkali of the stannate, the fixing of the tin is not affected, the stannate is washed off, and no preparing takes place. If this point is not sufficiently attended to, no good work can be done. The action of the sours consists in taking the soda from the tin; the latter becomes insoluble, and attaches itself to the fibre, forming an excellent ground to receive colours, and, being colourless itself, not interfering with the purity of the white parts of the design.

Salts of tin cannot be advantageously used as mordants in the way of red liquor and iron liquor in calico printing; that is, by printing and afterwards dunging and dyeing. They take colours, but not satisfactorily, and the shades produced are very loose—much looser than steam colours. They do not stand the clearing operations necessary to obtain good whites. Madder red mordant is often mixed with crystals of tin, sometimes with

a view of enabling it to resist colours printed over it, sometimes with the intention of brightening the colour. Such a mixture is subject to irregularities in the dye, depending apparently upon the quality of the red liquor used. There are cases in which the alumina seems to be nearly all displaced by the tin. The red looks very well out of the dye, but is much injured in the soaping and clearing.

Salts of tin are much used in woollen dyeing and printing; and, owing probably to the difference in structural arrangement of the fibres, produce colours which for permanence leave little to desire. The stannate of soda cannot be beneficially applied to woollen goods as a prepare, on account of its alkalinity, which is detrimental to the fibre. It is usual to employ the acid solutions of tin, as the oxymuriate, sulphomuriate, &c., from which the woollen fibre easily abstracts the required amount of oxide. The same remarks apply to silk, which, however, is very rarely submitted to such a preparatory mordanting.

The colours produced by tin oxides differ from those of alumina and iron, bearing more analogy to those from alumina than to the iron colours. Solutions of tin decompose with greater facility than those of either iron or alumina, and the oxide will become attached to cloth under circumstances in which not a particle of the other oxides could be deposited. But cotton cloth does not seem capable of holding it in a large quantity; a small quantity it retains with a pertinacity which has no analogy in the cases of the other mordants. Similarly, tin has no great capacity for colours, or it has no strong retaining hold of them. A tin mordant can be dyed up and the colour almost soaped out, and the mordant left able to dye again. Tin is most useful, and forms the best colours when in presence of a large excess of colouring principle.

Other Metallic Mordants.—The remaining mordants of a metallic nature may be all classed together, being unimportant in themselves and generally only useful in combination with iron or alumina.

Sulphate of Copper is used in some cases of dyeing, as in logwood blacks, and frequently where sumac is employed. It is a very feeble mordant itself, if it even deserves the name; its useful action will no doubt be of another nature, namely, its oxidising properties, which have been frequently alluded to. Some of the oxide of copper does attach itself to the cloth and colouring matter, which fact may justify its claim to be considered as a mordant, but, if used by itself, the colours it would yield would be worthless. Copper may be considered as the mordant for the arsenical green, but that is wholly a mineral colour.

Nitrate of Copper is used by printers and dyers, but it is more as an

oxidising agent than as a mordant ; it is always used in conjunction with some other mordant.

Acetate of Copper is sparingly employed for the same purpose as the nitrate ; it is milder and feebler in its action.

Salts of Zinc.—The mordanting powers of zinc are very feeble, its affinity for the cloth is slight, and its attraction for colours but little better. It has been used as a mordant for murexide, with which it gives an orange yellow. Salts of zinc are often prescribed in calico printing to be mixed with iron and alumina mordants, but this is with a view of facilitating the adhesion of the real mordant ; it hardly ever happens that any zinc remains attached to the cloth, it is washed off in the cleansing.

Salts of Mercury.—These salts can never be much used as mordants on account of the difficulties attending their application, the only use to which they have been yet applied is in the case of the murexide purple or red. The mordanting powers of the other metallic salts accessible to the dyer and printer are so feeble as not to require any further mention than may be found concerning them under their respective metals. Some of the metals, at present too scarce and dear to be applied in the arts, seem to possess powers of combination with colouring matters which might be made available to the dyer. Such are the salts of nickel, cobalt, vanadium, and uranium ; but even these, so far as they have been tried in the laboratory, do not yield new shades or colours with known dyestuffs, but usually give the same class of colours as the iron mordant, with but little modification of tint. It would require more extensive trials to ascertain their actual utility, and their scarcity prevents that.

MORDANTS OF THE VEGETABLE AND ANIMAL KINGDOMS.

The tannin matter of galls or sumac and the peculiar acid of catechu are to a certain extent colouring matters, but they possess also some of the characters of mordants. They can combine with the fibre, and they facilitate the further combination of mordants and colouring matters with it. This constitutes a mordant according to our definition, but they are not mordants similar to the metallic oxides, but hold a place between them and real colouring matters. They can themselves produce colours with mordants, but they cannot without other mordants attract colours to any useful extent. They should be looked upon as exalting the powers of other mordants rather than as independent mordants. Cloth which has been galled or sumached exercises a greater affinity for the alumina mordant than cloth which has not been so treated, and the

combined galled and alumed cloth has a decidedly stronger affinity for colours than the cloth alumed without the galls. This is the real degree to which the astringent matters act as mordants. Picric acid upon woollen and silk seems to act the part of a mordant besides being a colouring matter; experiments appeared to demonstrate that wool which had been prepared with picric acid had a greater affinity for colouring matters than wool not treated, but it was not much, and the effects might be really owing to the colouring matter of the picric acid.

Oil.—The use of oils as assisting cloth to absorb and retain colouring matters is of very ancient origin. It is used chiefly in Turkey red dyeing, and appears to be an introduction from the East, improved as to the manner of its application by the science of our own time and country. It plays a part similar to that ascribed above to the astringent principles, capable indeed of acting as a mordant by itself, but producing thus only dull and feeble colours; but, combining with other mordants, elevating their affinities and communicating stability to the colours produced by them. It seems necessary that the oil should undergo some chemical change upon the cloth before it is fitted for use as an assistant mordant; this change is most probably an oxidation. The oil which has been exposed upon the cloth for some hours or days is evidently altered in its properties in some way or other; it is not removable by the same agents which act upon quite fresh oil; and though the oil most proper for this purpose never passes to the resinous state of the drying oils, it loses a great deal of its greasiness, and may be supposed either to have partially dried up or to have formed some saponaceous combination with the mordant, by which its oily nature is disguised. We have no information as to the *rationale* of the Turkey red process; it is a series of empirical treatments perfected by practice and long years of experience, which science is as unable to improve as to explain. The Industrial Society of Mulhouse offer a prize, and have done for many years, to any person who can give a satisfactory scientific explanation and justification of the Turkey red processes, but the prize remains unclaimed or unawarded; a sufficient proof of the little knowledge possessed by chemists upon the matter. What can be said is, that the oil enables the cloth to take the mordant more readily and in greater quantity. If one end of a strip of calico be dipped in the emulsion of oil and ash used by the Turkey red dyers, and placed for a few hours in a warm place, the fatty matter will be found to have contracted a permanent adhesion to the cloth, and if put into a madder dye it will be stained of a dull red, not possible to clear off by the usual clearing processes. If this strip, one end of which has not been in the oil, be boiled in a weak solution of alum for some minutes and

then dyed in madder a more striking difference is seen. The oiled part dyes up a red of no great depth, but in great contrast with the other end, which remains colourless. These two experiments indicate clearly, firstly:—that oil itself can attract colouring matters; and secondly, that it possesses some power of withdrawing the alumina from alum which is not possessed by the fibre. This is nearly all that is clearly known of the properties and uses of oil; besides assisting in the attraction of the colouring matter it communicates to it a permanence when fixed. This can be readily understood upon general principles as attributable to the presence of the oily matter, covering and shielding the changeable colouring principle from the action of the destructive natural agents to which it is exposed; an effect which is partially supplied by the use of soap in other cases. An illustration of the affinity of oil for calico and colours occurred to me in an unexpected and puzzling manner, and its recital may be of some use perhaps to others. A number of pieces having been printed in wrong colours for madder dyeing were discharged, after about a week's age, and before dyeing. The colours were for black, chocolate, and purple; the discharge was simply a warm souring and slight chemicking to take the yellow off the cloth. The pieces were printed again with various others some weeks afterwards, and dyed as usual, but they showed the old pattern through the back of the piece, and though not strong, it was sufficient to spoil the colour on the face and job the pieces. At first I suspected the pieces had been originally printed in red with crystals of tin in the red liquor, and it is well known that the tin cannot be removed without a bowking or strong spirits of salts treatment, and pieces for discharging containing that colour were kept separate. By testing the unprinted tab ends I was certain there was no iron left on the cloth, but neither could tin be detected. As tin is not easily found by chemical tests when in very small quantities, the non-detection of it did not prevent me still attributing the re-appearance of the pattern to it until, upon examination, it was found that those patterns had never been printed in red, and they were traced to the precise lot spoken of as being printed in black, chocolate, and purple, and it was evidently the black outline which showed through the other colours to their injury. It was some time before I fixed upon the oil, which was used in the colour, as the cause of the mischief, but I proved it very satisfactorily by various experiments. Only about a half noggin was used to a gallon of colour, yet it had fixed upon the cloth, and had gone through the hot sours, washing and chemicking, to re-appear as a mordant several weeks afterwards. It was easy to prevent the repetition of this accident when once its cause was discovered. It is probable that

the chemicking, and the time which elapsed between the discharging and subsequent dyeing, enabled the oil to become oxidised and quite fast. If the pieces had been reprinted, and dyed soon after discharging, I think the colour, attracted by the oil, would have disappeared in the soaping. Not all oil produces this effect, it is only an exceptional case I believe, for evidently the acidity of the mordant is not favourable to the oil forming an intimate union with the fibre; it is, on the contrary, in the presence of alkalis that it combines most effectually with the material of the cloth.

Cloth is oiled, in Europe, by means of an emulsion made with pearl ash—as stated under the head of oils—but in the East, where the natives still produce the finest and fastest reds known, it is applied in many various ways; but it appears that the best informed of them adopt a plan similar to the method in use with us, that is, diluting the fatty matter by some liquid which brings it, if not into solution, at least into a state of very fine suspension and division. Many of them, however, plunge the material to be dyed into the neat oil, and work it there, wringing it out, and exposing it to the air. Many kinds of oil are used; in Europe it is generally an inferior quality of olive oil, but in Asia, fish oil, lard, and other fatty matters are successfully employed.

Animal Matters acting as Mordants.—It was observed long ago that fowls and pigs which ate madder had their bones, if not their flesh, tinged with its colouring matter. It was also long known that egg shells take up dyes, and give a variety of agreeable shades. Eggs wrapped in dyed cloths, and boiled in water, abstract a portion of the dye from the textile material, and fix it on the shell. Both bones of animals and shells of eggs contain, besides animal matter, a large proportion of mineral matter, and this might be the basis which attracted the colouring matter. But it is found that when the animal matter is separated by any of the means well known to chemists, that the mineral matter has no such affinity for colours; some affinity it has truly, but very slight, and producing quite distinct results as to shade and fixity. Several animal matters have of themselves an affinity for colouring matters, and can be made the medium of applying them to cloth. But they are not mordants in the strict sense of the word, as iron and alumina are mordants. It cannot be shown that any of the animal matters adhere to fibrous substances by chemical attraction or affinity for it. Their adhesion is of a grossly mechanical nature. Take albumen, for example; when applied in solution to the cloth and dried it can be removed by washing in lukewarm water, even if it be allowed to age a long time. It exists upon the cloth as gum water does, penetrating the fibre, but,

being soluble in water, removable from it. But albumen coagulates under certain circumstances, the separate particles which move freely on one another in the raw white of egg become organically changed by heat; they assume a fibrous nature, are no longer soluble in water, and being thrown into this state, when mixed up with the fibrous material of the cloth they become inextricably entangled with it. The adhesion is very complete of its kind, but not comparable to that of the metallic oxides in its nature; it is more like the needle and thread affinity which one piece of cloth has to another sewed upon it. But the affinity which the animal matter thus fixed has for colouring matters seems to be of a chemical nature, at least there is no good grounds for supposing that the property which they possess in this regard is not an essential property, and depending upon the chemical constitution of the material. The knowledge of chemists upon this point is very defective indeed.

The mordanting powers of albumen, caseine, and lacterine, are not applicable to many useful purposes. The chief efforts made in that direction have been towards communicating, by their means, to cotton cloth an affinity for colours comparable to that which is enjoyed by woollen. A considerable share of success followed these attempts, and it has been demonstrated that it is possible so to prepare cotton cloth that it can receive colours of great brilliancy and tolerable stability, from materials which have no affinity for it in its unprepared state. Commercial and economical difficulties have for the present nullified these efforts, but there is no doubt that, with increased knowledge and experience, they will be again tried, with valuable results to the arts of dyeing and printing. Reference has been made to Broquette's patent, and, under aniline, the employment of albumen as a veritable mordant has been explained.

The superior affinity which woollen cloth enjoys for many colours may cause it to be looked upon as a natural mordant, but that would be a loose way of considering its properties. It does not apparently contain anything like a mordant, any more than cotton does. If it can be looked upon as containing a mordant it must be considered as wholly a mordant, and many have fallen into this error, and have imagined that by dissolving the wool in alkalies, and impregnating cotton with it, they could induce cotton with the stronger affinities of wool. The results have shown the fallacy of this line of reasoning. Cotton may be as reasonably considered a mordant because it takes the indigo blue from the lime and copperas vat, as wool because it can take blue from sulphate of indigo. The explanation of these differences must be looked for, not only in the various chemical constituents of the fibrous matter, but

also in the physical structure of the fibre itself. There recently appeared an account of the possible application of the newly discovered solvent for wool and silk, viz., the ammoniuretted solution of oxide of copper and nickel. The statement was to the effect that the solution of silk could be applied to cotton fabrics, to give them the appearance of silk. This is quite false; the appearance and properties of silk do not depend upon the amount of carbon, hydrogen, oxygen, and nitrogen which it contains, so much as upon its physical structure, and it would be as true to say that a heap of sawdust was a piece of timber, as to say that dissolved silk was the same as fibrous silk; the chemical elements are there, but the structure is for ever gone.

That the whole of the affinity of woollen and silk, and some other animal matters, for colours is not due to their physical organisation, is proved by their possessing powers of withdrawing colouring matters when all trace of structure has been destroyed by acids, alkalies, and solvents. I mean all structure which has been owing to growth and gradual development. But in this state of disorganisation they approach in properties to many other of the neutral and insoluble bodies. It is possible that if dissolved wool or silk had any affinity for fibrous matter their powers of attracting colour might be utilised, but they do not adhere in the slightest degree when deposited from alkaline solution upon cotton; as soon as the fluids have dried, the precipitated animal matter can be shaken or brushed off.

The use of albumen and other coagulating matters in fastening pigment colours has been sufficiently explained; it is only mentioned here to say that it has nothing of the mordanting qualities in that employment.

CHAPTER XXVII.

ON THE THICKENING OF MORDANTS AND COLOURS FOR THE PURPOSES OF PRINTING.

In dyeing, the mordant is applied in its fluid state ; the object being simply to impregnate every part of the fibre in an equal manner with the mordant and colouring matter. In printing, it is required that the mordant shall be applied only to certain parts of the cloth, the remaining part being either left white or occupied by some other mordant or colour. The capillary attraction of the fibres is such, that if a drop of mordant in its fluid state be applied to a piece of cloth, it spreads in a circular form far beyond the size of the drop placed on, but not in an equable manner ; the spot upon which the drop was first placed holding the greater part of the fluid, and the surrounding portions less and less as they are further removed from the first boundaries of the drop. This inclination of liquids to spread beyond the limits of their first application is overcome by the addition of various matters to them called thickenings, such as gum, starch, etc. These substances act by themselves setting up an attraction which disputes more or less successfully the capillary attraction of the fibre, and retains the applied mordant within the limits of the design.

This is the first use of thickening matters ; a second is to permit the application of a larger quantity of mordant to the cloth than could be managed with thin liquors : this property of thickenings is sometimes taken advantage of in dyeing where no design is required.

The use of the thickening matters employed in calico printing is simply transitory ; while most of the other substances employed carry some traces of themselves on the finished product, the gum, starch, and flour employed as thickenings are only temporary in their application,

and have to be all removed before the colours are finished. The great expense of the thickening matters, and the complete loss of all the raw material, should draw the attention of printers particularly to this point, to see if it is not possible by mechanical means to dispense with the use and waste of such large quantities of substances which are for the most part derived from articles of human food. The Industrial Society of Mulhouse, always alive to the wants and necessities of printing, have offered a prize to any one introducing into the market thickening matters capable of replacing those now in use and not made from articles used as human food. I believe it is possible to go higher than this, and to ask for some means of doing without thickenings altogether. I am convinced that this is possible and practical, and that the skill and ingenuity of mechanical science will not be long turned in this direction without reward.

The art of thickening colours lies at the very root of calico printing; upon it depends so much in the way of obtaining good results that it may be considered as the most important part of colour mixing, and that a colour mixer will be good, bad, or indifferent, as he intuitively perceives the importance of this branch of his art, and is successful in carrying it out. To give receipts and furnish the best materials is nothing, without there exists at the same time an intelligence to comprehend the action of the various materials, and an ability to put them together in such a way that they can produce their full effect. Good receipts fail in the hands of unskilful colour mixers, and the purest and most expensive drugs are only thrown away; while an expert hand can produce good colours from inferior articles and at less price. The difference all lies in the putting together of the materials, and the properly blending them with the thickening matter most suitable to them and the particular styles they are intended for. It is not possible in a book to enter into all these matters with the minuteness they deserve, nor to communicate all the knowledge necessary to success; it is so much a practical matter that after all has been said that can be upon the subject, a great deal more that is essential will be left unsaid, for no description or formulæ can explain what the finger and thumb can feel, or the accustomed eye perceive, in a made up colour. Such generalities upon thickenings as will lead to the understanding of particular cases will be given here, and other connected matters may be found in the section on gums.

Many mineral matters, such as pipe clay, white lead, gypsum, and the like, could prevent the spreading of a fluid mixed up with them; but all mineral matters of this nature are heavy, not soluble in the fluids, and consequently fall to the bottom, leaving the supernatant

liquor thin, and of course producing irregular results. Such substances cannot be generally used by themselves; when in combination with some of the vegetable thickenings they are frequently employed to give density and toughness to the paste, and are thus particularly useful in resists. There may be colours of such an excessive chemical activity, that the vegetable substances employed in ordinary circumstances are acted upon to the mutual destruction of both the thickening and the colour. Such are chromic acid and the permanganate of potash; if the application of these is necessary or useful it will have to be through the medium of some mineral thickening like pipeclay.

The vegetable substances used for thickening colours may be divided into three classes: first, starches, flour, and thickenings insoluble in cold water; secondly, gums proper, whether natural or artificial, which are soluble in cold water; and, thirdly, artificially made up mixtures of the first and second classes, partly soluble and partly insoluble, partly gummy and partly pasty.

The thickenings of the first class require a much less weight per gallon to give the desired viscosity to a mordant than those of the other two classes. This is their first and most striking characteristic, and it will be well to consider here the influence which the weight or mass of thickening has upon a colour, without taking any of the other properties into consideration. Good starch thickens sufficiently well for most purposes at twenty ounces per gallon of water, flour at about the same or a little more, and gum tragacanth gives a consistent colour with only one half this quantity; on the opposite side, calcined farina requires eight or nine pounds to be added to a gallon of water to bring it to a proper state of viscosity. Is it indifferent whether a colour or a mordant be thickened with starch or calcined farina? It is not only not indifferent but a matter of the greatest importance. As a general rule, it may be stated that the smaller the quantity of thickening in a colour the darker the shades produced. If iron liquor at six or seven degrees Twaddle be thickened with starch or flour, a good black may be obtained from it in the madder dye; if the same strength of iron liquor be thickened with calcined farina, it will not dye up a black but only a shade of purple. To obtain a black from calcined farina thickening would require the iron liquor to be at least double the strength given. The same rule holds in other colours; the depth of shade is always in some ratio to the amount of thickening matter. The mass of thickening impedes the access of the particles of the mordant or colour to the fibrous substances intended to receive them. It is evident that if the colour was made of an excessive degree of thickness, none of it would leave the thickening

to go to the fibre; it is only because the thickenings contract upon drying that the fibre receives from them any of the colour or mordant enveloped by them; and in proportion as this contraction is greater or less in relation to the original bulk of the matter when applied, so is the amount of colour or mordant communicated to the fibre. Starch swells out when boiled into a bulky vesicular mass, which may be looked upon as a sponge holding the liquor with which it was boiled; the drying of the starch on the cloth is equivalent to the squeezing of the sponge, the liquor leaves it because it can be dried up into a small compass. Calcined farina, when dissolved, may be looked upon as a sponge also, but one of a denser kind, with less room for liquids and more difficult to squeeze dry because of its solidity. When it dries on the cloth a good share of the mordant or colour never touches the fibre, being entangled by the intervening mass of the thickening with which it remains in contact until washed away in the cleansing or dunging.

Another and dependent effect may be noticed, that is, the penetrating power of the different thickenings. Printed with rollers of an equal depth of engraving, it will be found that the starch or flour thickened colour has penetrated through the cloth, and shows plainly and strongly upon the reverse side of the piece, while the calcined farina thickened colour has penetrated much less, and may not be at all perceptible upon the back of the piece. The observation of this, and the knowledge that the colouring matter, which is visible on the wrong side of the piece, costs the printer money without adding to the effect produced, leads to questions concerning the economy of thickening matters in a comparative point of view. One pound of starch will cost less than five pounds of calcined farina or other gum; but there is a possibility of this difference being wholly or partially made up in the quantity of madder required. If the watery starch colour permits the metallic mordants to penetrate to parts where they exhaust the dyeing material without adding to the colour, it becomes simply a matter of calculation and trial to ascertain if this does not over-balance the difference in the cost of the gum and starch. In madder dyeing it is not only a question of economy, but of goodness of colour, not to let the mordant penetrate too deep into the centre of the fibre; for the deposition of the colouring matter only takes place in a perfect manner upon or near the surface: it is there only that the mordant becomes saturated, and its natural colour overcome by the true lake formed. Below the surface an imperfect combination only takes place, which, in the case of alumina, results in brick-coloured reds, and with iron mordants, in rusty snuff colours. These form a bad basis for the real madder colours, and injure their

shades. Beyond a very small extent it is, therefore, injurious to the colours to have them deep seated in the cloth; the whiteness of the cotton is the best ground for them to show upon, and a colour is better in proportion as it is upon the surface, or even appearing to stand in relief. These remarks apply principally to madder purples and pinks, but are equally true of light dyed colours. For dark shades it is necessary sometimes to penetrate the cloth, or, at least, it seems necessary; but, I believe, with management, better and cheaper colours could be obtained by keeping on the face side only.

Only the two extreme cases of thickness have been mentioned, but there are many intermediate degrees from which the colour mixer can choose, to accommodate his colours to the necessities of printing. The second class of thickenings are those which are best adapted for all light shades of colour. They appear to be less subject to irregularity than paste and starch colours, and give better furnished and fuller shades, at the same time they are livelier and brighter, which may be attributed to them being more superficial than the paste colours would be. The third class, or mixed thickenings, form a very useful class, capable of valuable application. By a judicious use of them the valuable qualities of both paste and gum may be in a great measure combined, and economy of thickening matter secured, without waste of dyewood. Gum manufacturers send such gums or mixtures out into the trade, some of which are good and some bad. A colour mixer has it in his own power to make nearly all useful mixtures of this class from the *bona fide* gums, sold by respectable manufacturers, and the starch and flour with which he is supplied. In making mixtures of various thickening substances, it should be taken as a principle that those will work best together which have separately the greatest similarity in properties. It is not well, for example, to mix starch with calcined farina; they are at the opposite ends of the scale, and are too widely different in their properties to work smoothly together. The mixture will separate, the thick part leave the thin, and work rough and curdy in the machine. If a mixture of starch and gum is wanted, some gum should be chosen whose thickening power is about four pounds per gallon, and there ought to be more of it by weight than the starch to form a good mixture. If it is required to strengthen calcined farina with some substance thickening further than it, a gum should be chosen thickening at from four to five pounds per gallon. A mixture of calcined farina and flour will work well if it contain also a certain quantity of gum whose actual thickening point is about the same as the calculated mean of those two substances. It acts as a medium, holding the

extremes together. Two gums which are perfect gums will mix and unite in any proportion without subsequent separation, and whatever their respective thickening powers may be. In mixtures of various thickenings it will be found that flour and starch give body and firmness, the natural gums give tenacity, and among these tragacanth is conspicuous, the true artificial gums give solidity or density. There is much good to be done by this method of mixtures ; it often happens two or three individual gums of an inferior quality will give, by proper mixture, a good useable gum.

The adaptation of the thickening to the design is so much a practical matter that it is scarcely possible to go into details. The lighter and finer the engraving the smoother and solider the thickening should be ; for fine outlines a good paste colour is suitable, or else a smooth dense gum colour ; a soft puffy colour would not answer, although this latter would be suitable to blotches. For fine covers, in light shades, gum colours are best adapted, but paste colours can be often used with advantage.

The other particulars necessary to the understanding of the actions of thickenings are to be found in the remarks on ageing and on gums.

CHAPTER XXVIII.

DUNGING OR CLEANSING BEFORE DYEING.

THE term "dunging" was applied to this process naturally enough, because nothing but the excrements of cows were formerly used for the purpose; but now that it seems probable that the use of cow dung will be given up the continuance of the name is unnecessary. The process is frequently called "cleansing," which is an appropriate name, since the real use of the process is to clean the cloth from loose matters which would interfere with the dyeing. The name is sufficiently distinct from "clearing," by which is understood processes subsequent to the dyeing. M. Persoz proposes to change the name of dunging into "fixing of mordants;" this, besides being a somewhat clumsy expression, is expressive of a theory which may not be true, since the fixing of the mordants takes place before dunging, if not wholly, at least in great part. I shall adopt the word "cleansing," as sufficiently expressive, and on the whole preferable to the term dunging, which is in many cases obviously incorrect at this day.

After the thickened mordants have been printed on the cloth, and exposed a sufficient length of time, they are ready for dyeing, in so far as the mordant has become fixed, and not removable by water. But there has been a great deal of mordant applied to the cloth which either never comes into contact with it or is more than it can absorb and retain. This is removable by water, and, if the pieces were to be placed in the dye vessel, would dissolve, and seriously interfere with the dyeing. If the pieces were washed in water simply before dyeing the object would be partially attained, that is, the loose mordant would be removed, but another difficulty would occur, the excess of mordant liberated at one point would be absorbed by the cloth at another where the design

required a white or colourless part ; or, in case of different mordants being on the same piece of cloth, they would intermix and spoil one another ; the red would turn the purple into chocolate, and the blacks would give a purplish colour to the reds. It was necessary to find some fluid in which the pieces could be washed from the excess of mordant, and the now useless thickening matter, which at the same time should prevent the loose mordant from being at liberty to fix itself upon any part of the fabric. Such a fluid was found in a mixture of hot water and cow dung. There were always some objections to the use of cow dung, and a desire for the possession of some substitute. Although the cow dung left nothing to desire as far as the cleansing was concerned, the supply was not regular—in certain localities it was scarce—and the animals have had to be kept near to the printworks, actually for the sake of their dung. In other places the supply fails in the summer months, when the cows are grazing, and their dung is spread over large surfaces ; add to this the unpleasantness of working in such a material, and it will be easily understood why substitutes have been called for, and are now very extensively adopted. The action of cow dung will be first treated of, and then the properties of some of the substitutes in use.

The analysis of cow dung does not point out any particular principle in it which can be said to be the active agent in cleansing. Its power has been at various times attributed to each of several substances in it ; its albumen, and its peculiar animal matters, were supposed to be the active elements in it ; again, the mineral matters it contained were said to be the real principles which were useful in it, and so on in turn every single element has been at some time or by some person considered the essential matter in it. That cow dung does not possess any principle peculiar to itself, which enables it to be used for cleansing, is plainly evident from the fact of the successful employment of substitutes which have no resemblance to it in any way. But that it possesses some principles that fit it for such a duty is evident, but it does not seem necessary to fix upon any single one as the essential one, but rather to view the action exercised as one resulting from the combined influence of two or more of its constituents. My observations and experiments have led me to conclude that cow dung owes its efficacy to two things, namely, the finely ground up or chewed organic matter, the remains of the hay, grass, or other food of the animal, and to a species of greenish olive colouring matter which is present. The effect of a passage in dung appears to me in great part to be mechanical, and to be an illustration of the power of surface in attracting chemical matters. The undigested fibrous parts in the dung fix upon themselves the excess of mordant as soon as

it leaves the piece, and so prevent it spreading either on the whites or the neighbouring colours. There is no difficulty in considering that this would be a sufficient explanation, if it were allowed that the insoluble parts of the cow dung could exercise this affinity for the mordant which is set at liberty by the liquor. When it is considered that the chemical composition of the fibrous matter of cow dung, and its physical constitution also, resemble very closely that of cotton fibre, it is not difficult to imagine it as having at least as great an affinity for the mordant which is loosened as the surrounding cotton fibres themselves; but because it is in a finer state of division, and in contact with the actual particles of mordant, it has an advantage over the cotton fibres which are at some distance, and could only receive the excess of mordant through the medium of the bath, consequently the superfluous mordant is retained by the insoluble floating particles of the cow dung. This action of the cow dung I consider all that is essential to it; it has other actions upon the mordant and cloth, but they are either of no importance in their result, or only of secondary importance. The colouring matter referred to seems to act an useful part, but it is not clear what it is. The mordants take it up and retain it through the washings, but in the dyeing it is driven out by the stronger colouring matter of the madder or garancine. If a fent mordanted for black and purple be dipped in hot caustic soda at one or two degrees of Twaddle, it will come out with the mordants of a light buff shade; in this state they do not dye well in madder. The colours produced are poor, and it takes a longer time and higher temperature to dye them. If the fent be taken from the caustic soda to a regular passage in dung it soon changes its colour, acquiring nearly the same shade as if it had been at once passed into dung; in this state it dyes up well and quickly. The change of colour may be attributed to the absorption of colouring matter from the cow dung; and the better colours produced upon dyeing and the shorter time required must be attributed to some action of the cow dung, not necessarily to the colouring matter, but the weight of probability is in favour of it. Some actual chemical change in the mordant is possible; if any, it must be in the way of deoxidation. I have found a decoction of cow dung to act powerfully as a deoxidising agent.

It may not be accepted as a fact that the presence of the colouring matter of the cow dung would facilitate the dyeing, but I am convinced it does, and especially in madder colours. Practical experience shows that in the case of the best dung substitutes a final wince in cow dung is advantageous. It is better for the oxide acting as a mordant that it should go into the dye beck in a partly saturated state than in a state of the

highest activity : in a majority of cases the colours will be more solid, brighter, and faster when the combination between the mordant and the colouring matter is slow and gradual, than when, on the contrary, it is rapid and completely effected in a short time. In the case of madder this might be explained upon the assumption of a variable displacing power of the true and false colouring principles present in it. It may be supposed that the dun colouring principle cannot displace the colouring matter of the cow dung, but that the alizarine can do so, and does so by degrees in the course of the dyeing ; and it may be supposed that by this means a pure colour is produced, which suffers less in the clearing operations than if the mordant was partly filled with the easily removable secondary colouring matter of the madder. In other colouring matters it may be considered that they cannot combine so rapidly with the mordant, because it is partly combined already, but this combination is a weak one, and gives way to the power of a stronger agent, and being formed slowly, seems to be more stable ; just as in painting, a thick layer of paint, equal to the whole quantity required, might be applied at once, but it would not be so good as if applied in two or three separate coats.

Dung Substitutes.—The dung substitutes at present in use are chiefly the arsenite and arseniate of soda, the silicate of soda, mixtures of the two, and various compounds containing other substances in addition to those named, but whose utility is of a very questionable nature. As mentioned just now, caustic soda would act as a dung substitute for black and purple mordants, but not for red mordants, because the alumina forming a soluble combination with the alkali would be entirely removed. The silicate, arsenite, and arseniate of soda may be looked upon as caustic soda, the more energetic properties of which are modified by the arsenical and silicious acids. The alkalinity is modified, not destroyed. The same may be said of the carbonates, bi-carbonates, and phosphates of the alkalies, which have been sparingly used as dung substitutes. The chemical action of these substitutes differs from that of cow dung ; for while I do not look upon cow dung as possessing any notable fixing powers, it is certain that the arsenites and silicates do enjoy such a power. They actually neutralise the acid remaining in the mordant, and precipitate the oxide upon the cloth in greater quantity than dung, and under different circumstances. At the strength at which the substitutes are employed in the cleansing apparatus, very little of this precipitation of oxide upon the cloth actually takes place : the action of the substitute is confined to rendering the loosened mordant insoluble at the moment it quits the cloth, and so preventing its combining with

other parts of the fabric. But if the strength be increased, the precipitation upon the cloth takes place, and darker colours are produced—of course at the expense of the dyeing material and frequently also at the expense of goodness of shade. It is not well that the cleansing liquor should be also a fixing liquor; in ordinary cases of calico dyeing the two processes should be distinct.

Besides the chemical salts spoken of, other substances have been used for dung substitutes, such as bran and flour, but they are neither economical nor effective.

Dunging or cleansing is one of the most important parts in dyeing for calico printing; it deserves the utmost attention of the superintendent, for upon it depends in a remarkable manner the success of the dyeing. The heat of the cleansing liquor and its strength must vary with the styles, and be skilfully adapted to them. The rule is to use such a temperature and strength as will cleanse effectually, and not to go beyond that strength and temperature. The nature of the thickening must be attended to; if it is a gum thickening, and one which is easily soluble in water, the temperature may be kept low, but the strength must be rather greater than for paste thickenings; if a mixture of paste and gum thickenings, the heat must be higher and the strength medium; if all paste, the heat must be high and the strength of the liquor entirely in proportion to the kind of printing—being the strongest for blotch and heavy covered patterns, and weaker in proportion as the pattern is lighter. As a general rule the heat should be kept at the lowest point, this may be as low as 100° F. for light plate patterns without black; for black and acids for madder work a temperature of from 140° to 160° is the best; for garancines the temperature must be high, but need not exceed 180° F. in the first cleansing. For light reds and purples, especially for the former, a low temperature is necessary to success. In styles which contain much acid, as also in those which have a large quantity of red in them containing crystals of tin, the addition of chalk to the cleansing dolly is very useful. The cleansing is usually divided into two parts; the open passage of the pieces by means of rollers through the "dolly," and the fly wincing afterwards. About two minutes is all the time necessary in the first liquor; that is sufficient to fix the loose mordant and to loosen, but not to remove, the thickening. The second cleansing requires a longer time and a rougher motion of the pieces in order to remove all the thickening matter from the cloth; it may take from fifteen to twenty minutes or even longer if the nature of the thickening is opposed to easy solution. There must be no stinting of time; the cloth must be well cleansed or there will be nothing but

confusion in the dyeing. The pasty thickenings sometimes get into a state very difficult to deal with ; they swell out but do not dissolve from the fibre, adhering to it like a jelly ; rapid motion is necessary to detach them or some mechanical appliance. The clear substitute liquors do not act so effectively in this case as cow dung, its insoluble matter acting mechanically upon the cloth, scours it by attrition ; probably if some light substances like sawdust were added to the substitutes their energy would be increased. It is not usual to wash the pieces between the cleansings, except by simply passing them through clear water ; it is very necessary that they should receive a perfect washing after the last cleansing—about fifteen minutes in a dashwheel or three to six passages through a washing machine, depending upon the style and nature of the thickening. I have tried the effect of a brush revolving against the open piece in the first cleansing to help in detaching the paste thickening ; it acted very well, and if applied near the end of the dolly cannot do any harm. This or some similar mechanical appliance may be beneficially used when the thickening does not come off well ; but under ordinary circumstances it is not necessary, the motion of the pieces in the beck and a good washing with plenty of water will generally suffice to remove all adventitious matter and leave the cloth clean for dyeing.

CHAPTER XXIX.

ON THE DIRECT APPLICATION AND FIXATION OF COLOURING MATTERS—
FASTNESS OF COLOURS—DYEING IN GENERAL—EXTRACTS FOR DYEING.

General Considerations.—Theoretical Views.—The nature of the combination which takes place between colouring matters, mordants, and fibrous substances, has been the subject of considerable difference of opinion among writers upon dyeing. In the last century, Hellot and Le Pileur d'Alpigny enunciated an opinion, which may be called the mechanical theory; they were opposed by Bergman and Macquer, who sustained a chemical theory. The ideas of the first two authors, as translated into current chemical language, are of such a nature as to command every respect. They do not admit of any chemical affinity on the part of the fibre, but rest their arguments upon an assumed porousness of all fibres, and, further, that the pores of one fibre are of a different size to the pores of another of a different origin, and that the number of pores is greater in some cases than others. Wool was held to have pores of greatest diameter, and in a given space the greatest number of them, and silk those of least diameter. These pores, which they supposed to pierce the fibres laterally, were the recipients of the coloured particles; they were expanded by heat, and various chemical agents, in such a way as to admit the particles of colouring matter, and then, being closed by cooling or other chemical agents, were enabled to retain them securely. They, of course, allowed the influence of mordants as changing the shades of colour, and as forming insoluble lakes with the colouring matter. To explain why dyes would not enter into combination with all fibres equally, the theory of different sized pores was invented, and then different sizes attributed to the particles of colouring matters. These assumptions serve to explain most phenomena in dyeing, and after the following

manner :—Wool has the greatest number of pores, and of the largest size, therefore it stands at the head of all fibrous substance in its affinity for colours ; silk has pores much smaller, and is more difficult to dye, and never attracts so much colouring matter as to give the dark shades obtainable on wool ; cotton holds an intermediate place. But there are colouring matters which do not dye wool so well as they dye silk and cotton fibre. This is explained by saying that those colouring matters do truly enter into the pores of the wool, but they are of too fine a nature to be retained there—they swim out again upon washing—they are deficient also in some astringent principle, which in other colours contracts or shuts up the pores ; when they are applied to silk or cotton they meet pores of a narrowness suitable for them, and are retained. The difference between fast and loose colours is in connection with the above phenomena ; a fast colour is one in which the size of the coloured particles is adapted to the size of the pores of the material on which it is applied, and in which the colouring particles either contain in themselves or there is in the mordant some astringent or binding substance which causes the contraction of the pores ; a loose colour arises from an unfitness between the size of the pores and the colouring particles, and an absence of the astringent principle. The particles are either too small, and pass too readily in and out of the pores, or they are too large, and only partly enter them, and the astringent principle is either absent or too weak to close up the pores in a firm and enduring manner. Hellot insisted a good deal upon the astringent principle, and considered that the essential difference between dyewoods lay in their relative astringent power, saying that if this principle could be communicated to those which were deficient in it all colours would be alike fast colours.

The theory of Hellot rests entirely upon the supposition of the actual existence of pores in fibrous substances. It has been objected that this is gratuitous assumption, for the most perfect microscopes of the present day show no lateral pores, but only a central tubular structure, in either vegetable or animal fibres. But apart from microscopic evidence, or rather the want of it, there is every reason to deduce from analogy that the walls of the fibres are permeable to fluids, and therefore contain some kind of passages or pores. No real ground for objection can be taken on the score of want of microscopic confirmation ; the microscope is a progressive instrument, and can only be of value so far as it approaches to perfection in its powers, and it is far short of that. From mathematical and physical grounds, if not from our knowledge of organised structures in general, there is reason to predicate the porosity of fibrous matters. The further development of the theory which

asserts the size and number of these pores to be different in different fibres, is in like manner supported by analogical reasoning. The naked eye discovers in the fibre of wood, sections of vegetables and fruits, and in some minerals a regular difference of structure, a coarseness or a fineness, which is always the same for the same substance; in amylaceous matters the microscope shows a regular difference in the relative sizes of the largest granules of any two qualities of different origin; the globules of potato starch are invariably larger than those of wheaten starch, and these are larger than the globules of other kinds of starch. It is not, therefore, exceeding the bounds of fair analogy to suppose that the pores of fibres of a different origin may be different in size. The further assumption that the pores of wool are greater in size than those of silk or any other fibrous matter does not rest upon such general principles, it is deduced from the behaviour of fibrous substances towards colouring matters, which behaviour might be explained in other ways.

The chemical theory considers the fibre as having an attraction of a chemical nature for the colouring matter or for the mordant; that a real intimate union of atom to atom takes place; it throws aside the question of porosity as not necessary to the explanation, and looks upon the dyeing as an union upon the surface of the fibre between it and the colouring principle, with or without a mordant. The various conditions of the fixing of a colouring matter, the different mordants and treatments necessary, are looked upon as arising from the different chemical properties of the respective fibrous and colouring matters. This theory has been the one accepted by the majority of writers upon dyeing, but as these writers are for the most part chemists, it is not, perhaps, wonderful that they should have adopted a chemical explanation, and made a free use of such terms as affinity, attraction, and combination; terms which for the most part are very loosely used, and include too much to mean anything precise.

Mr. Crum published a paper a few years ago upon this question, and supported with great ability the non-chemical theory so far as the fibre was concerned, admitting of course a chemical action between the chemical materials used, but looking upon the fibre as a neutral ground upon which the colouring matter was formed, but retained there by purely physical means. He rejects the idea of any deposition of permanent colouring matter upon the surface of the fibre; to be able to resist washing, the colour must be, he says, actually inclosed by the fibre as by a bag or a fine net work, the colouring particles must be in the cells or pores of the tissue; in madder dyed goods there is a chemical compound of an oxide with the colouring matter, but there is no chemical union of

either of them with the cotton fibre. There can be no chemical combination, he considers, with the fibre, for "if we only consider that chemical attraction necessarily involves combination, atom to atom, and consequently disorganisation of all vegetable structure; that cotton wool may be dyed without injury to its fibre, and that that fibre remains entire, when by chemical means, its colour has again been removed, we shall find that the union of cotton with its colouring matter must be accounted for otherwise than by chemical affinity." He admits a power of attraction on the part of cotton fibre, and a capability of its withdrawing chemical or colouring substances from solutions of them. But in this force he only recognises that same action, whatever it may be, which enables charcoal to absorb gases, and remove colouring matters and some salts and metallie oxides from solutions. The blue vat, the plumbate of lime for chrome oranges, the nitrate of iron, and muriate of tin passages so familiar to dyers, are examples adduced; but they are not examples of chemical attraction but of catalytic force.

Mr. Crum's theory has been controverted by Mons. Persoz at some length in the second volume of his work upon calico printing; but in my opinion he does not meet Mr. Crum's arguments upon the exact ground of the experiments and deductions of the latter; and most of his illustrations from calico printing and dyeing are directed against ideas which are not contained in Mr. Crum's paper, and which are not fairly deducible from what it does contain. M. Persoz considers that cotton fibre and other fibres have an actual influence of a chemical nature upon salts; he states that cubical alum left in contact with cotton fibre loses alumina, and becomes converted into ordinary alum; and that acetate of alumina is much more completely decomposed upon cotton cloth than when it is exposed spread over a similar surface of glass, mica, or platinum, which are chemically inactive. He rejects the idea of colouring matters being held by cells, pores, or bags, chiefly on the ground that colours when deposited on cloth are as easily acted upon as in any other condition; that if there were such cavities, they would be filled up in many cases by the materials used preparatory to the application of the actual colour, as by the oil and astringents in Turkey red, by the oxide of tin in steam colours, and by the oxide of manganese in indigo dyeing. He states that upon a careful examination of dyed or printed colours, it may be seen that the colour is upon the surface and in relief; if it were otherwise, he demands, how could thickened discharges penetrate into cells and perform their office, and how could the slightest washings suffice to remove colours so made soluble? The question of atom to atom combination, and consequent supposed inevitable disorganisation of the tissue,

he answers by referring to some unpublished work of his own and some peculiar ideas upon planetary and molecular attraction, cohesion, affinity, juxtaposition, and combination, of which I regret I cannot present any intelligible account. He considers, however, that there is a chemical combination between the colouring matter and the cloth, even in such a case as indigo dyeing; and evidently considers the fact of the fibre being unchanged or uninjured as forming no argument against the supposition of chemical and atomic combination. He proceeds at great length to prove that the adhesion of colours to fibres is simply due to attraction; but what M. Persoz means by attraction, in this particular case, I am not able to define. Upon intelligible definitions of those two words, "catalysis" and "attraction," used respectively by Crum and Persoz, the whole discussion rests.

The difference between the ideas of Persoz and Crum are very distinct upon the matter of pores: one thinks them all essential; the other either considers them not to exist, or, if existing, to be of no essential use. Crum's theory is a refinement upon that of Hellot, and Persoz's does not differ very much from it. Hellot uses the expression that colours are held by the pores of the fibre, as a diamond is by its setting; in Persoz's theory the diamond is held without any setting,—it adheres where it is applied, as two true surfaces to each other, or two edges of freshly-cut caoutchouc; for he does not assume that it is by virtue of those forces commonly known as chemical, but by some congruity of physical form that the mordant or colouring matter attaches itself to the external wall of the fibre. Both Crum and Persoz admit the existence of a positive attraction on the part of fibre for colouring matters and mordants; but neither of them consider this attraction to be that of simple chemical combination, such as takes place between an oxide and an acid.

Throughout these pages I have made use of chemical terms to explain the formation and retention of colouring matters, and have more than once referred to an active affinity as existing on the part of fibres for oxides and colouring matters. Upon a full consideration of all the circumstances of absorption of colour by fibre known to me I conclude that the idea of the fibre taking a chemical part is the one which agrees the best with all the phenomena. The great difficulty appears to be in the objection of Mr. Crum's, that if there was chemical combination there should be disorganisation of the fibrous structure when this compound is destroyed by the removal of one of its components—the oxide or the colouring matter; whereas, on the contrary, it is not found that the fibre is altered or injured in a conspicuous manner by several such successive

combinations and decompositions. I venture to think this objection is not of so great a weight as to decide the question. Admitting that chemical combination alters the physical characters of a body, I think it may be supported that there are several cases known to chemists in which the alteration is of such a nature as not to be observable without special precautions. I may cite gun cotton, for instance, which in the hands of most persons would pass for simple cotton, and if chemical combination be anything but a word to play with it surely exists here. In the case of the fatty bodies we are convinced that after having been saponified and the soap decomposed by acids, the fatty acids are not the same as the original fat ; but our senses would scarcely have given us this information,—it required the genius of Scheele and Chevreul to show where the difference was. In organic chemistry we have numerous instances of feebly acid bodies forming combinations not greatly differing in physical aspect from the acid itself. Mr. Crum seems to assume that the whole matter of the fibre must enter into combination with the colouring matter or mordant, just as Persoz assumes that the imagined pores are entirely filled in every case of dyeing ; but this never is the case in calico printing or dyeing ; only a small portion of the cotton or other fibre is supposed to be in actual combination, and if all this part was to be detached in dust upon the removal of the mordant or colouring matter with which it is combined, the fabric would probably be only weakened, not destroyed. Fibre is insoluble in all the menstrua used in dyeing ; such chemical affinities as it possesses are very weak, and it is next to impossible that an atom to atom combination of the whole fibre ever should be accomplished. When sulphuric acid acts upon carbonate of baryta or lime in mass the action is soon suspended, though sulphuric acid is one of the strongest and most soluble of acids ; how much sooner should the chemical action come to an end between bodies one of which is always insoluble and of a texture peculiarly opposed to the continuation of chemical action and other bodies which are at the best indifferent to it in their ordinary combinations. I know that a given weight of calico can be made to combine with, that is, to retain, various quantities of oxide of iron—that, in fact, this oxide may be placed upon it until the fibre loses its elasticity and may be broken like a glass thread. But this is not a case of intimate union with the fibre, it is a mere plastering on of oxide, and the possibility of breaking the fibre is owing to the foreign matter present ; so calico may be broken if water is frozen on it, or if it be made very stiff with gum. Mr. Crum merely says that dyed cotton fibre remains entire when its supposed chemical combination is destroyed ; that is so without doubt, but I am strongly

convinced that its integrity is injured. In numerous instances of discharging dyed goods, I have found a diminished strength in the cloth—it was thinner and softer to the feel, seeming to have lost body, and this was not owing to the discharging process, as I have tested by sending white cloth through the same process; it is well known that it is dangerous to discharge heavy printed goods twice over, the greatest care will hardly succeed in turning them out fit to be printed a third time as sound goods. But there is nothing like positive evidence of any real chemical union between the fibrous and colouring matters. Up to this time the composition of fibre is not known; I believe that the discovery of its solubility in ammoniated metallic solutions will lead to some insight into its chemical characters; in the mean time, though I am a ready believer in the porous theory, I do not think it sufficient, and I believe there are evidences of chemical activity to justify the views I have taken.

But if all the phenomena of dyeing can be included or explained under a single theory, must it not be the theory of Hellot and d'Alpigny, with their various sized pores, their plasters and cements, and their astringent substances tying up the pores? This theory seems ridiculously mechanical, but, if granted, it will include all cases that I know, and certainly no other theory will. Picric acid dyes wool and silk but not cotton, sulphate of indigo the same; they are probably both contained in the undecomposed state in those fibres—the picric acid can be tasted and the indigo compound easily extracted. Do they combine chemically? That seems very unlikely; and if so, why not with cotton? If it is a catalytic attraction of surface, why does not cotton exert it here as elsewhere? If a different chemical composition of these fibres is adduced as the explanation, the pure chemical theory is at once granted; if a distinct physical structure is suggested as the explanation, Hellot's theory is adopted. A fabric, composed of cotton, wool, and silk, may be submitted to dyeing operations of such a nature that all three, or two only, or a single one, shall receive colour. In the case of muslin de laine (that is mixed wool and cotton) the dyeing of the two in different shades is extensively carried on. Wool absorbs mordants and colours from acid solutions, by which cotton is not affected; and, on the other hand, cotton can be dyed in alkaline fluids from which wool absorbs no colour. Yet neither acidity nor alkalinity are necessary conditions of dyeing upon either fibre; wool takes indigo well enough from an alkaline bath, and cotton iron from an acid bath. To dye a mixed cotton and woollen fabric indigo blue, it is necessary to dye the cotton first in the cold vat, where the wool takes scarcely any colour,

and then to transfer it to a hot vat, where the wool does take indigo, and where the cotton takes hardly any. Which theory explains this? The colouring matter of safflower is thrown into the insoluble state in order to dye with, and the operation is performed cold. What kind of chemical combination can take place under these circumstances? and how are the coloured particles to get into Mr. Crum's sacks, and be secured there? Heliot's pores are always gaping for them, like an open trap, but he admits not always shutting up when the object enters. Freshly precipitated chromate and sulphate of lead, when thickened and printed, do contract at once an intimate connection with the fibre, and are not to be removed from it by a simple washing,—yet these are insoluble salts, and not known to undergo any decomposition, or form any compound with the fibre. Turmeric and anotta are also difficulties hard to reconcile to any theory, but suggesting an active affinity on the part of the fibre. Though there is no agreement as to the part which the fabric takes in the formation of the coloured compound, there can be no reasonable doubt about the constitution of the colouring substance. In all cases where a metallic or earthy mordant is employed the colouring compound is a lake formed of the oxide and the colouring principle of the dyewood; most of the pure colouring principles appear to possess feeble acid properties, and the lake resulting from their union with an oxide may be considered a salt. Those colouring matters which dye without mordants, as indigo, safflower, etc., may for the present be considered as existing in the fibre unchanged.

The Stability or Fastness of Colours.—The term 'fast colour' has a very wide and somewhat indefinite signification. Under the old regime the French authorities attempted to define what was a fast and what a loose colour, and enacted laws bearing upon the matter, and prescribed tests to distinguish between one and the other. They prescribed a boiling in alum and water, then a treatment with weak vinegar and an exposure to the air, along with some other tests. If the dyed colour did not satisfactorily resist these tests it was condemned. Dyers were compelled to confine themselves to either fast or loose colours; the government prescribed what drugs gave fast and what gave loose colours, and prohibited, under a penalty, the dyer of the '*bon teint*' to have on his premises the drugs which were used in the '*petit teint*,' and vice versa. This was a barbarous system of testing the colours, most ineffective in its results, and speedily fell into disuse. Soap is considered now as the test for fastness in colours, but that is only a degree less absurd than alum and vinegar, though it gives some idea of the nature of the colours. *A fast colour may be defined as one which will resist the destructive*

agencies of the position in which it is intended to be placed. What is a loose colour on a print for a dress may be a fast colour for hangings or curtains ; what would be inadmissible on calico, which has to be washed frequently, would be a fast and good colour on silk velvet, which is not expected to be washed at all ; a colour which would be loose for a silken banner, exposed to sun and air and rain, would do excellently as an article of furniture or even as a pocket handkerchief ; and a colour which is well adapted to resist all the silent influences of air, damp, light, and heat, may totally disappear in the wash tub. If a colour is to be used upon an article of dress, its fastness should be tested by the way in which it will resist the agents to which it will be inevitably exposed. If a cheap calico dress pattern, it will have to resist much friction and the detergent action of soda and soap ; if a superior kind of calico or muslin, it will not be always necessary for it to resist the action of soap in a perfect manner, but it is expected that it will not fade upon exposure to good bright day-light, that it will not spot or stain with pure water, and that the colour will not be detached by simple friction either dry or in water. There would soon be an end to calico printing and dyeing if all muslins and calicoes were to be washed as shirts and blankets are washed, or expected to go through the same treatment uninjured. It would, doubtless, be desirable that colours should be produced of that degree of fastness, but there is no hope of such a result at present. All printed and dyed goods which are intended as wearing apparel, should, as a primary point, be required to withstand the action of air and water, but that is not required in an equal degree for all kinds of dresses. Promenade robes must be of more stable colours than is necessary for evening or home dress ; many colours which will fade by two or three days' exposure to air, will be good for weeks in the diffused light of a house or by gas or candle light, and for this kind of wear it is possible to produce rich and delicate shades which would be inapplicable for other purposes. There is no abstract fast or loose colour, they are all comparative, and all have their proper place. Turkey red and indigo blue are the fastest of all dyed colours ; that is, when exposed along with other colours to the action of water, friction, air, and light, they will remain uninjured, or but little injured, when the other colours shall be faded or completely discharged. The fastness of a colour does not depend altogether upon the colouring principle, for it is found that the same colour has very different hold upon different materials ; a cochineal colour is faster upon wool than upon silk, and faster upon silk than upon cotton, and this is generally the arrangement of the relative durability of the same vegetable or animal colouring matters, viz., more stable on wool than on

silk, more stable on silk than on cotton. There are exceptions to this rule depending upon the action of the animal matters in silk and wool upon certain colours; for example, Chevreul found that indigo upon cotton was capable of resisting higher temperatures than upon either wool or silk, and the same with safflower. The experiments made by this eminent chemist are very interesting in a philosophical point of view, but not practically, because he submitted the dyed goods to extra natural agents,—to high temperatures which are only to be found in bakers' ovens, and to gases which are known only in the laboratory. But it requires no scientific test to know that some of the colouring matters will only fix upon certain fabrics, and that if placed upon others they are very loose. The archil colours enjoy a fair amount of stability upon woollen, on silk less, upon cotton none at all. Silks dyed shades of violet blue with archil and cudbear are bleached by exposure to strong sunshine; but the colour is not always destroyed, it can be revived again, or it revives itself, if kept in a dark place for some days—this is often perceived in parasols, and in other colours besides those from archil. The silk under the influence of heat and light seems to exert some chemical action upon the colouring matter, similar to the lime and copperas action upon indigo, and probably it is a real deoxidation which takes place; analogy supports such a view. Upon cotton, colours seem to be affected in an opposite direction, and appear to be destroyed by oxidation. It is the nature of silk and woollen, by virtue of their higher organisation, to exert under the influence of chemical agents an attraction for oxygen; this property, which is common to all organic substances, is possessed in only a feeble degree by cotton, and its organic nature does not under general circumstances present an obstruction to the oxidation of the colouring matter upon it. Mineral colours for the most part are oxidised bodies, and owe their colour to the particular balance of the metal and oxygen in them; upon cotton fabrics this remains undisturbed as far as the cotton is concerned, and it is only external influences which can change them; but on animal tissues the fabric itself is a quasi-chemical agent, which, having an affinity for oxygen, generally takes it from any oxidised mineral substance, and thus altering the relative proportions of the elements destroys the colour. It is for this reason that the iron buff, which is an oxide of iron,—the manganese brown, which is a peroxide of manganese, and the lead puce, also a peroxide, cannot be applied on silk and wool with any good effect; it is the same with other mineral colours which are not simple in their composition, as the chrome yellow and orange. Other mineral colours are inapplicable on wool because of the sulphur it contains acting upon them and injuring them. It seems

probable that these properties of the different fibres may be at the bottom, and explain the various behaviours of the different colouring matters, both as affecting the union of them with the fibre and their degree of permanency when combined with it.

There is no general principle to guide the inquirer as to how a fast colour is to be produced. We know too little of the nature of the union between the mordant and the colouring matter, and between either, or both of these, and the fibre, to enter into anything better than metaphysical explanations which bear upon this part of the matter; no information can be obtained in that direction except what practice reveals, viz.: that some compounds are less stable than others, but without any information as to why. There is a reason for this no doubt, and when it shall have been discovered it is not unlikely it may lead to some improvements in the application of colours which shall make all fast alike, or at least add to the stability of those which are now deficient in this respect.

Temperature and Duration of Dyeing Operations.—Most colouring matters require heat to bring them into a state of combination with the mordant and fibre. A few are dyed as well cold as hot; and they are chiefly those which dye without mordant, as indigo and safflower. When a colouring matter has to be combined with a mordant, so as to give deep colours, heat is always employed; for light shades it is not always necessary; and when one mordanted colour is to be dyed on the top of another, it is usual to do it cold, because if heat were employed, the last colour applied would mix with the other colour, but it is only wanted on the top. In such cases the combination of colouring matter and mordant with the fibre is not of an intimate nature, and the result is in most cases a fugitive colour.

The temperature to be used for dyeing varies according to the nature of the stuff and the colouring matter. Many colouring matters are largely soluble in water, and can be used as extracts: these do not require high temperatures. A temperature of 120° Fahr., or somewhat hotter than the hand can bear, is a heat at which dyeing proceeds very fast with most woods. At thirty or forty degrees higher the water is at the scald, and is hot enough for all dyeing operations at the commencement, and for the greater part of the time; towards the end, when the greater part of the colouring matter has entered into combination with the mordant and stuff, the heat may be increased to the boil, so as to extract as much as possible of the colouring matter, and to enable the last parts of the mordant to take it up. Boiling in the dye is not to be recommended in any case; it weakens the cloth, and subjects the colours

to several irregularities. In those cases where it is necessary, either on account of the depth of colour required, or to economise colouring matter, the less the better. A temperature of 208° or 210° will generally effect all that boiling can, and avoid the disorganising influence that rapid ebullition has upon vegetable fibres. The length of time which is required in dyeing is dependent on several circumstances connected with the mordant, the colouring matter, and the stuff or fabric. The mordant is sometimes in the soluble state, as in piece-dyeing, and there is no difficulty in its meeting the colouring matter, and forming the coloured insoluble lake which, being deposited on the fibres, constitutes the dye. In such a case the dyeing is more quickly performed than where the mordant is in the insoluble state, as in dyeing after printing. The mordant being fixed to the fabric, the formation of the coloured compound (instead of taking place through the mass of the liquor) takes place only on the fibre; the range of action being limited, the time required is greater.

The solubility of the colouring matter itself influences the rapidity of dyeing. In the case of the woods whose colouring principles are very soluble in water, the time is shortest; in the case of madder and garancine, the colouring matters of which are only slightly soluble in water, the time required is greater, other circumstances being similar. The lighter the fabric to be dyed, the less time is required to complete the operation. In heavy goods the colouring matters do not penetrate quickly, and it is necessary to subject them to reiterated treatments in order to obtain good solid colours. In heavy woollen goods, more remarkably than in cotton goods, it may be observed that the dye does not penetrate to the centre, or if it does, it is much lighter than upon the surface. In calicoes the dye goes through the single threads of the cloth, so as to appear the same in any part. It is a mere case of physical penetration, except that mordants and colouring matters are not like water—simply a fluid; but depositing matter as they penetrate, at every step it becomes more difficult to proceed, until at length the fibres are choked up with the mineral matter, and further access denied them. It is this difficulty of penetration of the dye which makes the difference in time of dyeing between heavy and light goods, taken in conjunction with the greater amount of colouring matter which it is necessary to deposit where there is a greater mass of fibre to cover. As noted under indigo, it is possible to prepare cloth in some cases in such a manner that it receives the colour more quickly than in its natural state. For example, the Mercerized cloth, and cloth prepared with sulphate of copper, take up the indigo dye much quicker than simple unprepared

cloth could do. Dyewoods can be prepared in some cases so as to give their colouring matter much quicker than in ordinary cases. It is possible from an alcoholic solution of the pure colouring matter of madder to dye up a purple in two minutes as good as would take two hours to obtain from the madder root.

Extracts for Dyeing.—Many dyewoods are of so hard a nature that they cannot be well used in dyeing in their crude state; it is necessary to make a decoction or extract of them, and to exclude the wood itself from contact with the cloth. This is the case with logwood, quercitron bark, fustic, and all similar hard woods. The sharp, angular, barbed fragments would adhere to the cloth in such a manner as would necessitate an unusually violent washing to remove them, while, from some kinds of heavy goods they could not be removed at all. Upon plain calico this objection is small; but even here it conduces greatly to the equality of the dyeing and clearing of the pieces to use extracts of this class of woods. Cochineal, madder, and such softer materials, may be employed in the gross, because the residuary matter can be easily detached by washing. The old plan of avoiding contact with the woody particles consisted in enclosing the dyewood in a bag of linen or sacking, and suspending it in the dyeing vessel. This method was very defective, because much of the colouring matter could not have been removed from the wood, and unless it was used over again it would be lost, besides the time required to have made even an imperfect extraction of the colouring matter would be much longer than should be employed in dyeing. The method in use now upon extensive dyeworks is to extract the colouring matter from the woods by forcing hot water through them, or by keeping them for a certain time in boilers in contact with hot water. The solutions thus made at some distance are conveyed by pipes to the dye-house. They are not concentrated like the liquors used by printers, marking less than one degree of Twaddle. Not more should be made in a day than can be used,—keeping does harm to weak extracts. As a general rule, it may be taken that the best way to keep a colouring matter is in its natural cells, and the sooner it is applied after leaving them the better. Thus, if no objections as above stated interfered, it would be better to use the rasped or ground woods in their entirety; the colouring matter would be more certainly extracted, and there is reason to suppose it would be in a purer and less altered state than after passing through various extracting operations, and having been exposed to the action of heat and air for variable lengths of time.

CHAPTER XXX.

METHODS IN USE FOR OBTAINING COLOURS FROM THE MATERIALS EMPLOYED.

THE methods in use for obtaining colours upon fabrics are very various, and exhibit a high degree of ingenuity upon the part of the originators. Some processes have doubtless arisen from an accidental observation, and many have grown up by slow degrees to their present perfect state. Science cannot claim to have originated any processes until quite recently; whatever there is admirable in the arts of dyeing and printing is due to the continued application, industry, and ingenuity of a long succession of practical workers. Looking at many of the methods of fixing colouring matters, we cannot but feel astonished at the adaptation of the means to the end, and wonder how in ignorance of chemistry the only substances which could effect certain solutions have been hit upon for that purpose. Nor has chemical science always succeeded in explaining the rationale of the methods adopted. We may understand the use of orpiment and potash in dissolving indigo, and the theory of the cold vat, but can only make guesses at the utility of certain drugs used in mixing colours and in dyeing, and the necessity for certain treatments. The steps which led the discoverers by slow degrees to the present results have disappeared in the obscurity of time; the results only being visible seem rather the effect of inspiration or accident than the usual reward of untiring industry and indomitable perseverance. It seems very probable that the researches of chemistry, combined with the technical skill of the practical man, will enable vast changes to be made in the methods of applying colours, for it is only now that the products of the laboratory are making themselves felt in the arts. In the following pages an outline of the methods of producing any colour upon fabrics is indicated; it is most convenient to range all the colours of

one kind together, however different their origin, thus under 'red' is found all the methods known and practised for dyeing or printing that colour, and so on with the rest. Weights and measures and minute practical details are omitted, because they are either unnecessary or delusive. Each locality and manufacture has its own peculiar difficulties to overcome, and requires special adaptations of general principles, known only to those engaged upon the works; if there is not intelligence in applying general principles, no formal prescription of pounds or gallons will avail, and, indeed, each colour mixer or dyer has generally more of such receipts than he can ever employ.

RED.

Red Colours, including Crimson, Scarlet, Pink, etc., upon Cotton Fabrics by Printing.—The chief colouring matters employed for topical colours are cochineal, sapan wood, and peachwood. With sapan wood and peachwood the mordant is acetate of alumina, usually mixed with an oxidising agent, as acetate or nitrate of copper, or chlorate of potash, or nitrate of alumina; oxalate of ammonia has been recommended as a suitable mordant in combination with chlorate of potash; oxalic acid is frequently added, in small quantities, to produce a clearer colour. Tin salts are rarely employed for steam colours, but good colours can only be obtained upon cloth prepared with tin salts. With cochineal the mordant may be acetate of alumina, with a little oxalic acid; or oxalate of alumina alone—seldom used.

Pink or red from fuchsine or azaëline is applied by means of albumen, fixed by steaming.

There are no good red pigment colours.

Spirit reds are from sapan wood, oxymuriate of tin, with, ordinarily, some copper salt and sal ammoniac.

Red from murexide is prepared by printing a mixture of the colouring matter and nitrate of lead; exposing to ammoniacal vapours, passing through water, and then into a mixture of bichloride of mercury and acetate of soda, and finally into dilute acetic acid or alkali, according to shade required. The red product is a compound of the murexide with the oxides of lead and mercury; it may be called a purpurate of mercury.

A scarlet, from iodide of mercury, can be obtained by printing a solution of iodide of mercury in iodide of potassium, and passing in bi-chloride of mercury. Madder red has for mordant acetate of alumina, fixed by ageing and dunging; or aluminate of potash, fixed by passing

in chloride of ammonium. Red to resist, or to discharge, contains chloride of tin. The mixture of gall nuts or sumac with madder gives a more scarlet red; the mixture of bran enfeebles the colour, and produces pink. Madder reds are changed to pink by a passage in dilute acid, or oxymuriate of tin, and soaping afterwards.—(For detailed observations on madder dyeing see madder purple.) Garancine yields good reds upon cotton, with an aluminous basis. The hypo-sulphite of alumina has been used for a red mordant. It is not usual to obtain any other reds than madder or garancine reds by dyeing after printing.—(For details upon garancine dyeing see chocolate colours.)

Upon Cotton Fabrics by Dyeing.—Turkey Red.—This colour has long been famous for its fastness and beauty; its preparation is long and difficult. The materials employed in its production are oil, galls or sumac, alumina and madder. The first step is to impregnate the cloth or yarn with emulsion of oil and expose it to the action of warm air; the treatment with oil emulsion is repeated several times until the fibre appears saturated. The excess of oil is removed by a steeping in dilute alkaline liquids. The next operation is the galling or passing in a mixture of alum and a decoction of gall-nuts; after a few days' hanging the fabric is cleansed and the mordants fixed in cow dung and ground chalk. The pieces are then dyed in madder, bullock's blood being added in small quantity. The galling and dyeing may be repeated to obtain the darkest shades of red. After dyeing the colour is brightened by several soapings, and sometimes by passing in dilute acids or oxymuriate of tin. There are several modifications in use; sumac may partially or wholly replace galls, and instead of alum, acetate or muriate of alumina may be employed; sheep and cow dung is sometimes used in the oiling, and a passage in nitric acid to favour oxidation.

Wood Reds.—Shades of red, crimson, and scarlet are obtained from the red woods by steeping the cotton in a decoction of sumac for some hours, then passing in dilute solution of a tin salt and working in decoction of the wood. Barwood, limawood, and peachwood, with various quantities of fustic and logwood, serve to obtain all the shades necessary. The sumac treatment enables the cotton to combine with more of the tin mordant than would otherwise be the case.

Pink is obtained from safflower by making extract of the colouring matter with alkali, adding an acid and working the material in cold; or from safflower extract by simply adding acid to the mixture of extract and water.

Upon Wool by Printing.—The only good reds upon wool are from cochineal or lac dye, the latter, being inferior, is only used for second-class

colours. For scarlet, chloride of tin, oxalic acid, or bi-oxalate of potash are used ; for crimson and pink, alum is the mordant, the ammoniacal extract of cochineal being necessary to obtain the best results ; some extract of Persian berries added to modify the shades ; bi-tartrate of potash and tartaric acid are also used in conjunction with the alum. Upon delaine the scarlet, crimson, and pink are the same as upon woollen ; but the two latter colours require more care in their preparation to avoid threadiness, that is, the want of colour upon either the wool or cotton threads ; if the colour be excessively alkaline the wool does not take it, if acid the cotton fails to receive the dye. By the judicious use of cream of tartar as an acid salt, and ammonia as the alkali, an expert colour mixer can readily hit the medium. A large excess of ammonia is used in extracting the cochineal, which must be expelled before the colour is made up, by keeping the colour hot, otherwise an excessive amount of tartaric acid is required which produces tartrate of ammonia, a salt unfavourable to the fixation of the colour. The red from murexide which can be communicated to woollen, though somewhat more permanent than upon cotton, has little to recommend it.

Upon Wool by Dyeing.—The chief colours are from cochineal, second class from lac dye, and very inferior ones from the woods. The scarlet from cochineal is one of the finest colours producible by art for brilliancy and stability. The mordant is tin, usually applied in the state of oxymuriate or bi-chloride mixed with cream of tartar, the wool cooled and drained, and then dyed with the cochineal and further addition of tartar, and sometimes tin salts. The affinity of wool for the colouring matter of cochineal is so great that the bath is left almost colourless when a proper proportion of cochineal has been employed, which is about an ounce of average quality to each pound of wool. The red from lac is obtained in the same manner. Shades of crimson and pink are obtained by aluminous mordants. Other colouring matters are occasionally combined with cochineal, either on economical grounds or to obtain a modified shade : except a minute amount of yellow, from bark or berries, such additions are to be avoided for the best colours. Reds can be obtained from peachwood and other similar woods, from an alum mordant.

Upon Silk by Printing.—The best red is from cochineal, with a tin mordant, modified by mixture of berry liquor ; but tolerable reds are obtainable from peachwood combined with alum, sulphate of copper, and occasionally with tin salts and tartaric acid, or bi-tartrate of potash. Pinks are from ammoniacal cochineal, with alum. Murexide yields a

fine red upon silk in combination with mercury. Various shades can be obtained by the application of fuchsine without mordant.

Upon Silk by Dyeing.—Cochineal, with bi-chloride of tin, yields the best colour. Safflower gives the finest pink. Fuchsine, azaëline, etc., yield fine and full shades of pink and red; murexide gives a deep colour. Common reds are obtained from peachwood and tin salts, with modifications of shade from fustic and anotta. Various colours approximating to red, and known as ruby, maroon, etc., are obtainable from cudbear and archil.

CHAPTER XXXI.

BLUE COLOURS.

Upon Cotton by Printing.—Prussian blue, indigo, and ultramarine are the only blues in use. Ultramarine, being an insoluble pigment, is only fast when applied by means of albumen or lactariné. Manufactured Prussian blue is miscible in acid oxymuriate of tin, and serves for an inferior spirit blue. The best steam blues are obtained upon prepared cloth by the decomposition of the prussiate of potash and prussiate of tin. A mixture for a best blue will contain yellow prussiate, sometimes a small quantity of red prussiate, prussiate of tin, tartaric acid, oxalic acid in small quantity, and, if the shade requires it, a little cochineal scarlet. For cheaper blues, the tartaric acid is wholly or partially replaced by sulphuric acid or bi-sulphate of potash, and the prussiate of tin by chloride of tin: alum sometimes enters into the receipts. As the prepared mixture is nearly white, a little nitrate of iron may be used to sighten it. Oxidising agents, chiefly chlorate and nitrate of potash, are occasionally introduced, but are of doubtful utility. There are many modified methods of putting steam blue together: ordinarily the starch is boiled with water only, while hot the prussiate is stirred in, when cooler the tartaric acid, then the prussiate of tin pulp, and lastly the oxalic acid, when nearly cold. The prussiate and tartaric acid may be mixed in hot water, when the bi-tartrate of potash will fall as a precipitate. The clear liquor contains all the blue-producing principles, and may be thickened with further additions of acid and the tin pulp. This method is more applicable to gum colours for blocking than to starch colours for machine. The chemical changes which take place are not accurately known. The acids cause the liberation of the ferrocyanic acid of the prussiate, which, at the temperature of steaming, undergoes another

change, losing one half of its cyanogen, as hydrocyanic acid; and the remainder forming a colourless compound with the iron, which only requires oxygen to become blue. The prussiate or ferrocyanide of tin undergoes some analogous change under the influence of the acids present, but the precise nature of it is not known. As the pieces are taken from the steaming, they are nearly white, but become blue by exposure to the air. As this exposure would be tediously long, it is shortened by passing the pieces through some oxidising agent before washing, generally bi-chromate of potash or weak solution of chloride of lime. The blue colour is immediately developed, but does not take its full lustre until after twenty-four hours' exposure to the air.

Indigo Blues by Printing.—Though the chief blue derived from indigo is by dyeing, there are two or three ways of applying this colouring matter topically to calico, so as to produce designs.

China Blue.—This blue appears to have derived its name from a resemblance to the shade of colour upon old china ware. It is produced by a process which is so extraordinary in its results that it is impossible to conceive how it originated. The indigo in its natural state is very finely ground, and mixed with deoxidising bodies, such as sulphate of iron, acetate of iron, orpiment, and protochloride of tin. In old receipts a great number of apparently useless substances are prescribed. Good results can be obtained by the addition of sulphate of iron alone to the indigo. As thus applied to the cloth, the indigo could be removed by washing. It is necessary that it should be deoxidised or dissolved in order to contract an intimate union with the fibre; for this purpose it undergoes a treatment somewhat analogous to that employed in dyeing from the same colouring matter.

After printing and ageing, to bring the colour into a proper condition, the piece is first dipped in clear lime water; this serves to wet it out and to form an insoluble or difficultly soluble compound of the gum, paste, or starch of the thickening with the lime. Since my experiments have convinced me of the existence of such a compound, the researches of M. Kuhlmann, of Lille, have demonstrated that such compounds are always formed under proper circumstances between starch and the similarly formed bodies and the alkaline earths. It is to the existence of this coating, pervious to water, but holding like a fine net the indigo particles in their place, that the first portion of the fixation of the China blue is owing. The piece is next placed in the copperas vat for ten minutes; the lime water which adheres to the cloth precipitates a little oxide of iron over its whole surface, but it does not appear that the slightest dissolution or deoxidation takes place. The piece is now moved to the

lime vat which has been raked up, and being plunged in is moved about with a gentle motion. What takes place here is at first a precipitation of all the oxide of iron of the copperas upon the cloth, along with sulphate of iron, together forming a thicker coat of slime; as soon as the whole of the lime is precipitated, the excess of lime begins to act (in conjunction with the protoxide of iron) to deoxidise and dissolve the indigo. The dissolved indigo has no tendency to spread beyond the design, for the reason that it is surrounded with fibres saturated with water, containing also a species of coagulum of gum and lime, and everywhere filled up with the slime of gypsum and oxide of iron,—no distant capillary motion is possible, and it is absorbed by the fibres in close contact with it; another reason is that an excess of lime prevents the solubility of the indigo to a great extent, and as an excess is present, the dissolved indigo cannot pass away from the spot where it was formed; in addition to this, there is the positive attraction of the vegetable fibre, which is strong enough to take away indigo from lime, and keep it intact even in the presence of the agents which could dissolve free indigo if presented to them. These considerations are, I believe, amply sufficient to account for the retention of the dissolved indigo on the spot where the undissolved blue indigo was placed in the printing. To complete the process the piece is again dipped into the copperas, and again into the lime several times, the number of dips depending upon the depth of the colour, the last dip is a long one in the lime. The pieces at the end of the process are covered with slime to the thickness of nearly half an inch; this is partly removed by a wincing in water, and then the pieces are turned over into sours, and left for several hours, so that all the iron may be removed from the cloth,—they are then washed and cleared in weak soap and warm sours.

Very dark shades cannot be obtained by the China blue process. It is a fast colour, but expensive on account of the time and labour it requires. In the old process of dipping on frames, which gives the best results, it takes about two hours to accomplish the dipping for the light shades, and twice that time for the darker colours. One man can only dip two long pieces at a time or four short ones, so that it is one of the most tedious and costly processes in use. A more modern method of raising is carried out in many places, in which the lime and copperas vats are supplied with rollers and the pieces passed through quickly; time is saved, but it is at the expense of quality.

A good quality of indigo should be used for a China blue, because in inferior qualities the resinous matters interfere with the regularity of the shade, but it is not necessary to have a first-rate quality.

Pencil Blue.—This blue receives its name from the manner in which it was applied to the cloth, viz., by means of a fibrous matter like an artist's pencil. It is a tolerably old colour, and no improvements have been made upon its preparation since the earliest accounts we possess of it; it is subject to the same difficulties in the application, and requires the same precautions. Pencil blue consists of indigo in the deoxidised and dissolved state. It is made by heating a mixture of finely ground indigo, orpiment, and potash. The orpiment and potash together form a powerful deoxidising mixture, which speedily reduces and dissolves the indigo. In a short time the blue of the indigo will have disappeared and given way to a yellow colour, except at the surface, where the oxygen of the air continually revives the indigo, and causes it to assume a coppery blue colour. The avidity of this mixture for oxygen, which restores the indigo to its blue insoluble state, is so great that it cannot be exposed a moment to the air without being covered with a scum or pellicle of blue indigo. It is this property which makes it so difficult to apply pencil blue in a regular and satisfactory manner. As soon as the block or roller leaves the colour and enters the air, the surface of the colour is covered with a scum of indigo, which, being insoluble itself, cannot enter into the fibre of the cloth, and being on the top of the soluble colour is an hindrance to its entering into the fibre. Peculiar arrangements have to be made in applying this colour, to prevent contact with the air; they are all more or less defective, and the results are seldom regular. In the old method of applying it with a pencil, the pressure upon the fibres of the pencil containing the blue could drive the film of indigo aside at the very moment when the pure colour beneath could enter into the cloth and unite with the fibre; but in either block or roller printing the cloth and design are perpendicular to each other, and the oxidised face of the colour comes in flat contact with the cloth, the insoluble particles being deposited first, hinder and prevent the fixation of the others. Many ingenious constructions of reservoirs and sieves for block printing have been made especially for this colour, and with the exercise of great care it has been possible to print with some of them, and obtain tolerable uniform results, but they have not admitted of general application. The difficulties in the way of roller printing are greater; and though it is possible to print it like any other colour, and obtain fast blues, it can only serve for styles of work where there is no particular demand for uniformity of shade. It is not possible to print five pieces of one shade in such a manner; and generally a single piece will be found to have two or three shades in it, an irregularity which would utterly condemn it for trade purposes.

The economical advantages of being able to apply a good dark blue by the roller are so apparent that it is not surprising that many efforts have been made to overcome the difficulties and obstacles in the way of the pencil blue. One of the most ingenious was made by Woodcroft, about a dozen years ago. Acting under the knowledge that it was the oxygen of the air which, both on the roller and on the colour, was the obstacle to its neat and proper printing, he proposed to construct covered apparatus to surround the colour box and roller, and to receive the piece when printed; and in all these spaces where the air was in contact with the colour, he proposed to expel it by introducing common coal gas from the gas pipes; this gas, not containing any oxygen, could not act upon the colour, which it was supposed would thus have a fair chance of entering the cloth. The idea was good, but, as may be imagined, the application was difficult in the extreme. Large sums of money were expended in giving it a trial, and all the resources of an extensive concern, combined with the best chemical information, brought to bear upon it, but without avail—it had to be given up. The exact point where it failed is not known, but it was deficient in many respects. It necessitated expensive alterations, and prevented the machine printer having that constant eye upon the colour, roller, and cloth, so necessary to success; a large escape of gas into the machine room was unavoidable, it annoyed the workmen, and rendered them either unable or unwilling to pay close attention to the printing; it was necessary to wind the pieces on a roll soon after leaving the roller, and in a vessel filled with gas; it was extremely difficult to prevent them marking off upon one another. Beyond these difficulties, which seem only to be of a practical nature, and surmountable by perseverance, there were others which were more discouraging, because they were unaccountable. The shades given by the same colour at the same printing were irregular. One piece would be several shades lighter than another, and the same piece a good colour at one end and bad at the other; there were streaks and cloudy work from bad clearing of the roller by the docter, and so many mishaps that it was dropped altogether in despair.

A new method of applying indigo was patented about two years ago under the name of Ward. The idea in this method is to accomplish a kind of China-blue dyeing without the vats. The indigo in the blue insoluble state is mixed with a deoxidising matter (preferably the substance known to chemists as grape sugar or glucose) and alkali, as soda and lime. Here are all the elements necessary to the deoxidation and solution of the indigo, but heat is required to bring them into operation. The colour is applied cold to the cloth; and as soon as the piece leaves

the printing machine, and without drying, it is passed into steam for about a minute. The heat of the steam causes the chemical reaction to take place, the indigo is deoxidised and dissolved, and enters the fibre of the cloth; it then requires washing and oxidising to bring up the blue colour. This plan has been put into practice in two or three places, but it is not likely to succeed either as a process of itself, or as presenting any economy in indigo or labour. The only use to which it can be advantageously applied is, when it is desired to combine madder or other dyed colours with the blue. It might enter into competition with the dip blue in resist styles, having a possible advantage in saving the cost of the resist and the printing. I have seen good dark blues from this process, but they are of a rather coarse nature, resembling dip blue more than any other style. I am informed that there are great practical difficulties in the way of applying other colours and mordants at the same time as the blue; and the steaming of the pieces before they are dry leaves them open to many and serious accidents. The published process will have to be much modified before it can be expected to take its place as a regular plan in calico printing.

Fast Blue.—Under the name of fast blue a colour is obtained from indigo on principles differing from any of the previously given processes. The indigo is applied upon the cloth in the white deoxidised state, but not in the soluble state. It differs from China blue by the indigo being deoxidised, and from pencil blue by its being insoluble. It is prepared in several manners; indigo, soda, and granulated tin are boiled together until all the blue of the indigo has disappeared, or ground indigo is mixed up with crystals of tin and soda in the same manner until it is all dissolved. When all dissolved it is precipitated by the addition of an acid or a salt of tin, the white indigo settles down mixed with oxide of tin as a greyish pulp. This is thickened and printed. The pieces are then passed through ash (either potash or soda); it requires the ash vat to be strong in order to get good results. The alkali of the ash vat renders the white indigo momentarily soluble, in which state it is absorbed by the fibre and constitutes the blue colour when oxidised by wincing in clear water. Although custom has given the title of *fast* to this colour it is really the loosest of all the indigo colours. This may be owing to the shortness of time given to it to enter the fibre and the excessive alkalinity of the fluid, in presence of which the indigo becomes soluble and has to contract its adhesion to the fibre. The depth of colour which can be applied in this way is limited; it is principally used in chintzes and furnitures as an addition to the other colours. If the other colours are liable to be affected by the alkaline nature of the vat they have to

be protected by a paste ; but as the fast blue is mostly used as a cover the same paste which resists the blue will resist for a sufficiently long time the action of the alkaline raising vat.

Upon Cotton by Dyeing.—The only fast and durable blue is derived from indigo ; blues of good shade and depth, but not capable of resisting alkalies, are obtained from the prussiate of potash and iron mordants. Inferior blues are produced from logwood, but generally with a basis of fast indigo blue ; they are recognised by a purplish reflection.

Prussian Blue.—This blue is usually obtained by preparing the cloth with strong solution of stannate of soda or souring ; then padding in acetate of iron, drying, and raising in prussiate of potash, acidified with sulphuric or hydrochloric acid. Other processes consist in alternate passages in nitrate of iron mixed with crystals of tin and yellow prussiate. A blue is obtainable from the red prussiate and mixture of nitrate of iron and crystals of tin. The presence of a good deal of oxide of tin seems necessary to produce dark and full shades of blue.

Indigo Blue by Dipping.—This colour is for blues what Turkey red is for the reds, the type of a fast colour ; resisting as long as the fibre all the influences of heat, light, and detergents. There are several different methods of setting an indigo vat, but the most usual is with sulphate of iron and lime, the indigo being in very fine powder. Other vats contain no sulphate of iron, but a mixture of alkali with various organic matters, chiefly bran ; a species of alkali, called Sussex ash, containing only a small per centage of alkali, but a large amount of sulphuret and silicate, is much prized for this kind of vat. In other cases urine, madder, and woad are employed, as also orpiment ; alkali of some nature is always present. The greater bulk of indigo blues on cotton are dyed by means of the lime and copperas vat, which is always worked cold.

The chemical phenomena of the deoxidation and solution of the indigo have been explained. It may be considered that the white indigo forms a compound with the lime water, but if so, it is a compound easily decomposed ; the oxygen of the air is absorbed by the white indigo, and it separates from the lime. The scum on the surface of a vat is due to the blue indigo formed in contact with the air and liquor. When cloth is dipped in this vat it becomes saturated with the liquor, and it is probable that an immediate combination is formed between the white indigo and the fibrous material ; but no coloration takes place until there is contact with the air. As the piece rises from the vat it is yellow ; it changes immediately to a green ; and within a short time to blue. The green is not an intermediate stage of the oxidation of the indigo, but a physical effect due to the yellow which is not yet changed, and the

blue which has been formed by contact with the air. Sometimes this change to blue does not take place well in the air, and the pieces are soured or exposed to some oxidising liquor, as sulphate of copper or weak bleaching powder. By repeated dippings there is an accumulation of foreign matters upon the cloth, which impedes the oxidation and requires that the piece should be a longer time exposed to the air : something of this will be owing to the nature of the indigo, the age of the vat, the quality of the cloth, style, etc. The best oxidiser is running water, if such is obtainable, if not, water containing a little sours, and as much movement about as possible. The use of sulphate of copper is not to be recommended ; its expense, if nothing else, would prevent its being employed to any considerable extent ; and the use of chloride of lime is dangerous. The fullest blue shade on calico cannot be obtained at a single dip ; or, if that be within the bounds of possibility, it is certainly neither practicable nor economical. The colour which is obtained by several successive dips is sounder, safer, and better, while the indigo in the vats can be used up to the greatest possible extent. From five to ten minutes in the vat, and the same length of time out, to take the greenness off the pieces, is found to answer very well. To obtain the darkest shades, seven or eight dips are required, which are usually given in so many different vats, beginning at the weakest and going on to the newest or that which contains the most indigo. For obtaining light shades of blue, the pieces are passed through a vat with rollers in a continuous manner. Only light shades are thus obtainable : the process is called "skyeying."

A blue vat is liable to be out of order from several causes well known to practical men, and not much known to scientific chemists. A vat may have too much lime or too little lime, and the peculiar defects of these cases are known under different names ; a vat is said to be *soft*, or *short*, *hard*, *quick*, *slow*, etc., but unfortunately soft and hard in one dyehouse do not mean what soft and hard mean in another. Too much lime hinders the solution of the colouring matter. Berzelius found that indigo made two different combinations with lime, one of which was soluble and the other insoluble ; the insoluble modification being formed from an excess of lime. This compound may be formed in a vat if an excessive quantity of lime be present, and therefore care must be taken that the quantity of lime is neither too much above nor below the quantity necessary. A vat which may be good for dyeing single blues may not be suitable for styles containing resists. There are, in fact, so many minor points to be attended to in a blue vat, that no one but a practical worker among them can expect to understand them. Various substances

have been used to enable the vats to give dark colours in shorter time than usual. Sulphate of copper, slightly thickened with starch and glue, is used to pass the piece through, it is dipped in lime and then in the blue vat, the consequence is that it abstracts the indigo with much greater rapidity than the same cloth unprepared, and also in greater quantity, yielding much darker colours. Other substances can be used for the same purpose, as the salts of manganese and mercury. Some dyers have fallen into the error of supposing that this plan of preparing cloth saved indigo,—it only saves time, and that will hardly ever pay for the expense of the chemical material employed. It is something worthy of notice that sulphate of copper should cause the cloth to attract the indigo so quickly, when the same substance also enters into the composition of resists, which have for object the keeping the indigo from fixing upon the cloth—and the same occurs with salts of manganese.

Upon Wool by Printing.—For dark blues only the same steam blue as upon calico is available; its composition is the same, but there is an advantage in using more red than yellow prussiate. The extract or sulphate of indigo, modified with cochineal, serves to give many shades of blue; some acid or acid salt must be used with it—oxalic acid, tartaric acid, acetic acid, and alum are used.

Upon Wool by Dyeing.—Fast blues are obtained from indigo by the hot vat, less stable blues from sulphate of indigo. Good blues are obtained from prussiate of potash, with iron and tin salts, working all the fluids hot. A species of blue, somewhat more expensive than the last, is obtained from the prussiate of potash, acids, and tin salts, without any salt of iron; it requires several hours to obtain a good shade, working at a high temperature.

Upon Silk by Printing.—Either a Prussian blue, as on calico, or a sulphate of indigo blue, or a mixture. An inferior blue is obtained from logwood, alum, and nitrate of copper.

Upon Silk by Dyeing.—Sulphate of indigo, with an alum mordant, gives many shades of blue; but the best are Prussian blues, dyed with nitrate of iron and tin salts for mordant, and raised in prussiate. Instead of ordinary nitrate of iron, a solution of sulphate of iron, in hot nitric acid, is preferred for some shades; such a solution may be called a nitro-sulphate of iron. A blue can also be obtained without the intervention of iron salts, as upon wool.

CHAPTER XXXII.

YELLOW COLOURS.

Upon Cotton by Printing.—Decoction of Persian berries and quercitron bark, with mordants of alum, acetate of alumina, and sometimes tin salts, are used for topical yellows. Salts of zinc and murexide give an agreeable yellow. The yellow from chromate of lead is only sparingly used; the mordant consists of nitrate or acetate of lead, or a mixture, or sulphate of lead; the oxide of lead is fixed by passing through warm dilute sulphuric acid or a soluble sulphate; the sulphate of lead is transformed into chromate by a passage in warm chromate of potash. Chrome yellows upon indigo blue styles are frequently obtained by printing an acid or acid salt upon chrome orange; nitrate of alumina is chiefly used as the acid salt.

Upon Cotton by Dyeing.—Very little pure yellow colour is dyed; the chrome yellow is most used; it is prepared by padding in sub-acetate of lead, fixing in lime water, holding oxide of lead in solution, and then raising in bichromate of potash. Other yellows are from fustic, bark, berries, and weld by means of the aluminous mordant.

Upon Wool.—The aluminous mordant and bichromate of potash, with bark, berries, or fustic. Picric acid, without mordant, gives clear transparent shades of yellow.

Upon Silk.—The same as upon wool. Nitric acid gives a yellow to silk which has been employed for handkerchiefs.

CHAPTER XXXIII.

BLACK COLOURS.

Upon Cotton Printed.—The topical blacks are generally composed of logwood and nitrate of iron, with addition of some of the other colouring matters to modify the shade. The old chemical black consisted of decoction of galls, nitrate and sulphate of iron. Black mordant for dyeing in madder and garancine is the ordinary iron liquor; for dyeing in logwood, iron liquor alone, or mixed with acetate of alumina, is used. A pigment black is made from albumen and prepared lamp black—it is more a grey than a black.

Upon Cotton Dyed.—Fast but expensive blacks may be obtained by dyeing a madder red upon a dipped blue; some yellow colouring madder, as bark or fustic, communicates a deeper shade. Logwood is the chief source of the blacks in trade, and copperas is the principal mordant; sumac, galls, sulphate of copper, and urine are also employed; fustic is used for the jet blacks. Blacks upon light goods are obtained from catechu, bichromate of potash, sumac, peachwood, and iron mordants; varieties of shade being obtainable by altering the relative proportions of the ingredients. The most durable blacks are those dyed upon a fast blue basis.

Upon Woollen Printed.—The ordinary topical black for woollen is a mixture of logwood, galls, nitrate and acetate of iron, and sulphate of indigo. Archil is also sometimes used, as also nitrate of copper, alum, and, for particular shades, cochineal, peachwood, and sapanwood are freely added.

Upon Wool Dyed.—The best blacks have a fast blue basis with a madder red superimposed; but the ordinary black is obtained from galls, sumac, logwood, etc., with the sulphate of iron and copper as mordants, dyed in the usual way near the boiling point.

Upon Silk Printed.—Logwood with nitrate of iron and a small quantity of nitrate of copper, is the only usual black for topical application upon silk.

Upon Silk Dyed.—The best blacks upon silk are derived from galls and sulphate of iron ; a great quantity of black pigment can be accumulated on silk, and its weight thereby increased as much as a hundred per cent ; an increase in weight from twenty-five to forty per cent is not unusual. Blue blacks have a basis of Prussian blue. Ordinary blacks are dyed from copperas and alum mordants in logwood, with addition of fustic for jet blacks ; soap dissolved in the logwood communicates bluer shades. The French writers upon dyeing speak of the bark of the chestnut tree as being much used in the black dye, and yielding satisfactory results both as to shade and economy. There are a great number of substances which may contribute to the obtaining of black upon silk, but the chief are those which have been enumerated.

CHAPTER XXXIV.

MIXED COLOURS.

IN the arrangement of the colours adopted in the following pages, the different shades are taken as they might be produced by admixture of the primary colours. Not that they are actually so produced by the mixing of the mordants and colouring matters yielding the primary colours, for in many cases chemical actions come into play between such mixtures, which give rise to colours totally distinct from the calculated optical effect, but the majority are obtained by the admixture of the constituent shades. Thus green is produced from blue and yellow, and orange from red and yellow colours; but in many cases there are natural colouring matters yielding secondary shades, such as the orange from anatto, purple from madder, and brown from catechu.

RED AND BLUE, INCLUDING ALL SHADES OF PURPLE, LILAC, VIOLET, ETC.

Upon Cotton by Printing.—Logwood and aluminous mordants, modified by mixture of peachwood, serve for steam lilac and purple; cochineal with copperas and alum gives a lilac. Spirit purples and lilacs are from logwood and oxymuriate of tin. Archil properly prepared, as in the patent French purple, gives very good shades, but requires albumen for thickenings; aniline gives also the purple shade known as mauve or mallow, but this also is not good unless applied by means of albumen. The actual admixture of red and blue colours would not produce any good purple upon cotton, but rather chocolates, or, if dark, blacks. Upon wool and silk there are blue colours which permit of being so mixed with red to produce purples.

Upon Cotton by Dyeing.—Nearly all shades of lilac, purple, and lavender are obtained from logwood and tin mordant; dark shades from

sumac, tin, and logwood, with or without an aluminous mordant. Light lavender shades can be obtained by dyeing a safflower pink upon a base of light Prussian blue. The purples from aniline and the modified archil are also applicable upon cotton prepared with albumen; aniline dyes up a lilac upon a lead mordant. Iron mordants yield shades of fast purple and lilac with madder; and as this is the only really fast purple upon cotton, and probably the most important colour used in calico printing, opportunity is taken to give a detailed account of madder dying.

Madder Purple and Madder Dyeing in general.—The mordant is diluted acetate of iron; one part of commercial iron liquor to four parts of water, properly thickened, will dye up a purple so dark that it passes for black; one part to eight of water yields the darkest purple, one part to one hundred of water yields the lightest shade required. The mordants are thickened, aged, and cleansed as before explained, and then entered into the dye. From causes already stated the madder is used in its entirety, because no extract or decoction of its colouring matter can be made; it is bulky and gelatinises in water, so that a considerable portion of this fluid has to be employed. But it is important to use no more water than is absolutely necessary for the easy running of the pieces; if an excessive quantity of water be employed a large portion of the colouring matter does not fix, and is either wholly lost or returns to the madder. The amount of madder will be for economical reasons apportioned as exactly as possible to the demands of the design; but, if it were not so, an excess could not be used without an injury to the dyed colours and to the whites;—to the colours, because the brown or dun coloured matter dissolving more readily than the alizarine, would fill up the mordants and dispute the entrance of the true colouring matter; and to the whites, because the free alizarine would partially fix upon them, and be difficult to remove. The alizarine dissolves only slowly and in small quantity in water, so that madder dyeing occupies a greater length of time than other styles: about two hours is required to obtain the best results; a less time than an hour and a half would waste madder; if continued longer than two hours at the usual temperatures the colours are liable to be injured without any corresponding economy of material. The mordants commence taking the colour at a temperature of from 100° to 120°, but only slowly; at 140° the dyeing proceeds rapidly, and could be wholly accomplished, but would not exhaust the madder; at 160° the colours become nearly saturated, and 180° is as high as it is advisable to carry the heat for the best colours. By raising the temperature to ebullition, a little less madder will suffice, but neither colours nor whites are at their best. As the dyeing does not commence

until a temperature of 100° is attained, the goods and madder may be entered in water at that heat ; in thirty minutes the temperature may be raised in a gradual and regular manner to 140° , and to 180° in another hour, keeping the temperature at that point till finished. Irregular heating is prejudicial to madder dyeing ; if the steam should be cut off and the dye fall twenty or thirty degrees in the course of the round, it would injure the colours very much. In France there is a system of dyeing madder colours at twice : dividing the quantity of madder into two unequal portions ; dyeing with the lesser quantity at a low temperature, and then in fresh water dyeing with the remainder, using more elevated temperatures. I have tested this plan with good qualities of French and Turkey madder, but found no advantage in colour, while there is greatly increased risk of accident, besides labour and expense ; it might be useful on poor qualities of madder. The exposure to the air during dyeing is by some authorities considered of essential benefit to the colours ; my experiments do not support that view ; I only found that the more the piece was exposed to the air, the more difficult it was to clear the whites ; for all that the air assists, the dyeing might take place in vacuum.

The costliness of madder, and the certainty that none of the existing processes extracted all its colouring matter, have led to the trial of numerous additions to it in dyeing, with a view of making it go further. The substances added have been mostly of the mineral nature, and have been used often at random, without any particular aim ; at other times they were employed with some specific intention as to neutralise some supposed acid in the madder, to counteract the effects of lime in the water, to prevent the fixation of the brown colouring matter of the root, to make the real colouring matter more soluble and so on. The advantages which are said to have been derived from the use of such additions to the dye-beck are more imaginary than actual. In the publications of the Industrial Society of Mulhouse may be found several essays on this subject,—some by anonymous authors, others with well-known and respectable names attached to them ; but the results are for the most part quite at variance with what can be obtained in England, working upon good French madder or Turkey roots. The most careful experiments that I could make in the same direction failed to give me the same results ; the madder which yielded such symptoms of being improved by certain additions could not have been like the madder supplied by respectable import houses in Manchester. The "*Bulletin de la Société Industrielle de Mulhouse*" is not easily accessible to English readers, but a full resumé of these papers may be found in Person

"*Traite de l'impression des tissus.*" The first point is the addition of ground chalk in madder dyeing. No one familiar with dyeing and printing can be ignorant of the letter which M. Hausmann wrote to M. Berthollet, detailing that he, having removed from Rouen to Logelbach, found that he could not dye up the same colours as those which he had obtained at Rouen; how at length, by analytical examination, he found the water at Logelbach was too pure, that the Rouen water differed from it by containing a quantity of lime-salt, and how he had the happy idea of adding carbonate of lime or ground chalk to the madder, when all the dyes came up well again, and produced colours as fast and brilliant as ever. Since the publication of this letter French writers hold it absolutely necessary that chalk should be in the water, either naturally or artificially, to produce good fast colours, and they consider that lime becomes an essential part of the colour as fixed upon the cloth. The statements concerning this necessity for lime are by far too general, extend over too long a series of years, and have attached to them too many of the names celebrated in the annals of French dyeing to be without some foundation in fact. But I can say, without fear of contradiction, that the Turkey roots and French madders used through a series of years in the neighbourhood of Manchester were never improved by the addition of chalk, even when distilled water was used for dyeing. Lime, in some form, is present in most samples of madder, and in France it is known that some madders are not only not improved, but injured by adding chalk to them. The madder called *Paluds*, from the district in which it grows, containing a large amount of chalk derived from the soil, requires no addition. The *Avignon* madder is said to require some chalk added, and the Dutch and Alsatian madders imperatively demand it in rather large quantity. Such is the general statement made by French writers. M. Persoz mentions a case in which he found a sample of Alsatian madder to dye up perfectly well without any addition of chalk; it had been kept for a considerable length of time in a bottle, and he assumes that it had undergone some change by lapse of time. An anonymous writer, quoted also by Persoz, puts down all the alkalies and alkaline earths and carbonates, including chalk, as injurious to madder dyeing; this is in contradiction to the current statements throughout his work, and especially to the statements of that eminent practical authority, M. Daniel Koechlin. The statements of M. Koechlin prove too much to sustain the lime theory, for he states that alkalies in general serve the same purpose, and prescribes the exact quantity of carbonate of potash and soda which are to replace the ground chalk. M. Persoz states that good madder colours contain a definite amount of

lime, and looks upon it as an essential constituent of the finished colour. I have analysed madder colours, but have not found lime as a regular constituent, and generally only found such traces as were due to the cloth itself. I cannot therefore concur in this theory of lime being necessary in madder dyeing as a general rule. Chalk is used to some extent in madder dyeing in many places. I do not know if it is general in England; to the extent of one pound in a hundred of madder it does no harm if it does no good. I have proved the presence of undecomposed carbonate of lime in spent madder when chalk has been used, at the same time the liquors have had an acid reaction to test paper.

Besides chalk, no other substance has been recommended for general use in madder dyeing, but exceptional cases are not wanting in which additions of various articles to the dye have been thought beneficial or necessary. Bran, for example, was long employed with madder in producing the old London pink. Size or glue has been and is yet used in some places under the impression that it gives better results, and enables the madder to dye farther; small quantities of potash and soda, as also oxalic acid and cream of tartar, are used, and may be beneficial owing to peculiar waters. The use of galls, sumac, and other astringent substances, does not come under consideration, as these must be looked upon as real colouring matters themselves, and as such adding to the result produced by madder, which addition may produce a simple exaltation of the colour, or an entirely different shade, according to the mordants in use. With regard to these substances which are used in madder dyeing without ill effects, those who employ them should be the best judges of their utility, and their opinion is worth more than that of a person at a distance and unacquainted with the special, and, perhaps, exceptional conditions under which they work. Nevertheless, a general opinion may be expressed, founded upon very numerous experiments made under a variety of circumstances, that with a fair quality of water and good madder no addition is necessary, no addition even is beneficial, and those additions which do not injure the madder only leave it where it was as regards its dyeing powers and the quality of the colours it produces. In the second volume of Persoz's work already cited, copied also in Muspratt's Chemical Dictionary, are a list of substances tried as additions to madder, and before them figures which pretend to indicate their beneficial or injurious action in dyeing. These figures are simply delusive, and bear upon the face of them evidences of their unreliable character. In the list will be found a statement, among others, that the addition of $\frac{1}{10}$ th of sulphate of potash to madder causes an increase in tinctorial power equal to 25 per cent, and further down that the addi-

tion of the same quantity of sulphate of soda diminishes the tinctorial power of the madder by 21 per cent, making a difference between the two of 46 per cent, or equivalent to half the quantity of madder used. This hardly needed the test of experiment to be discredited. I need scarcely say that no madder obtainable in Manchester was improved even one per cent by the addition of sulphate of potash, and I am certain, on the other hand, that sulphate of soda, used in the quantity laid down, did not injure it in any perceptible degree. The deterioration by sulphate of soda was more likely to be true than the improvement by sulphate of potash; and, in a repetition of the experiment, I provided an impure sulphate of soda which had been condemned as containing sulphate of iron, and by using a quantity of this, something greater than that prescribed, I obtained a deteriorated result, which could be carried to a perfect suspension of all dyeing powers in the madder by increasing the proportions. But it is evident that in this case it was the iron-salt and not the soda-salt which was injurious. Something of this nature might explain the minus result, but the plus 25 per cent of the sulphate of potash is inexplicable. Other substances, which are placed on the same list as injurious, are for the most part really so, but those which are marked as beneficial and improving the results of dyeing, sometimes to a very considerable extent, may be placed in the same category as sulphate of potash. I have tried them almost every one, viewing the results practically and commercially in comparison with pure madder colours, and I have not found any improvement in any case, but generally deterioration. There is hardly a chemical salt in either practical or laboratory use which I have not made trial of as an addition to the madder dye for lilacs, reds, and blacks, and there is not one which gave an improved result which was of the value of the salt employed, and nine out of ten acted prejudicially, altering the shades, robbing the madder, staining the whites, or stopping the dyeing altogether.

After the pieces have been well washed out of the dye, they are boiled with soap. The use of soap for clearing madder colours appears to have originated with the Turkey red dyers: its object in prints is two fold; first, to clear the colours from a dingy red colouring matter, which spoils their shade, and, secondly, to make the white parts of the design bright, by removing any colour which is attached to them. It is considered least injurious to enter the pieces into the soap solution at a boiling temperature, or at the highest temperature which it is intended to employ; two or three soapings are necessary for the best quality of colours. A good deal of colouring matter is lost by soaping; I have made many attempts to clear and brighten colours without removing a

portion of the colouring matter, but with very little success. Some eminent French authorities consider that the fatty acid of the soap enters into combination with the oxide of the mordant, and at once contributes to its stability and beauty. There is reason to doubt this statement in the ordinary cases of madder dyeing; beyond the difficulty of imagining such a combination as taking place under the circumstances, there is the certainty that, in many analyses, no fatty matter is detected, and that purples are produced of great beauty and stability from commercial alizarine, without the use of soap or fatty matters. No detergent answers so well as soap to remove the injurious brown colouring matters. The alkalies, caustic or carbonated, the borates, phosphates, and silicates are all injurious to the colours. A final clearing is given by padding in solution of bleaching powder, and steaming, or in the beck. In French processes a passage in weak sours, between the soapings, is often prescribed; this gives a weaker purple, with less of the red tinge, and would be preferred in some markets.

Tolerable purples are obtained from garancine; but they are not so fast as the madder purple. Commercial alizarine yields good and fast purples; but unless soaped, they are wanting in the soft finished appearance of the best madder colours. Madder purples are distinguished from all others by the magnificent purple colour they produce, when treated first by sulphuric acid, at specific gravity 1.4, and, after washing, plunging in lime water.

Upon Wool by Printing.—The mixed shades of red and blue upon wool can be obtained by mixture of cochineal red and blue, derived either from sulphate of indigo, or Prussian blue; but more generally from the former. There is no difficulty in obtaining any modification required.

Upon Wool by Dyeing.—Cudbear alone yields shades of claret and violet; a passage in dilute acid communicates a red tinge; and a passage in ammonia a blue shade. The cudbear can be also combined with logwood and peachwood, upon an alum basis. Very superior, but expensive purples, are dyed by dipping a fast blue, and then dyeing a cochineal crimson upon it; another colour, less expensive, consists of a mixture of cochineal, logwood, and peachwood, upon an aluminous basis. Logwood upon an alum and tin basis, and cudbear and archil, with sulphate of indigo, serve to produce an infinite variety of shades. A rich purple may be produced from alloxan by saturating the wool with it, and exposing it for some days to dilute ammoniacal fumes. Fast shades of purple are produced from the aniline coloured compound, by simply working the cloth in the colouring matter, with addition of tartaric or acetic acid; they are made bluer by having a Prussian blue basis, and

redder by archil. The solid French purple gives shades of violet, much superior in permanency, to those obtained from ordinary archil compounds.

Upon Silk by Printing.—Logwood chips, steeped in acetate of alumina, yield a lilac mordant, which is the basis of most shades of this nature upon silk; the shade is modified by admixture of cochineal red upon one side, and sulphate of indigo upon the other, to any required degree.

Upon Silk by Dyeing.—The oxymuriate of tin and logwood serve to produce all the shades of lilac, violet, lavender, peach, mallow, etc.; modifications of shade are obtained by the use of sulphate of indigo and archil; and by passage in weak solutions of soap. Aniline, and the modified archil, give more permanent, but more expensive colours.

RED AND YELLOW MIXED COLOURS, INCLUDING ORANGE, BUFF, NANKEEN, STRAW, SALMON, FLESH, ETC., ETC.

Upon Cotton by Printing.—Steam orange from Persian berries and tin salts with a little cochineal red; bark or fustic may be used instead of berries, but they produce duller colours nearer to nankeen. Anotta, dissolved in potash and neutralised by acids, yields an orange of the buff shade without mordant. Buff from iron salts is generally obtained from the acetate of iron fixed in milk of lime. The mordant treatment for chrome orange is the same as for yellow, the colour being changed by passage in hot alkalies, lime, or soda. A topical chrome orange can be produced by thickening freshly precipitated chromate of lead, and adding oxymuriate of tin. For dyeing an orange in garancine styles, acetate of tin is used as mordant, and berries added to the dye. The sulphurets of arsenic and antimony have been used for shades of orange and buff.

Upon Cotton by Dyeing.—The same materials as for printing, with little modification. Nitrate of iron yields sufficient iron oxide to give a light buff to cotton. Spirituous solution of saffron has been used to top chrome oranges.

Upon Wool by Printing.—Simple mixtures of red and yellow colours in the proportions required to produce the shade; bark and berries with bichloride of tin being used for the yellow, and cochineal scarlet for the red part.

Upon Wool by Dyeing.—All shades may be produced by mordanting in tin and tartar, and using mixture of fustic and cochineal. Turmeric for yellow, and lac dye for red, are occasionally used. Weld is also some-

times employed in combination with madder for woollen goods that require much finishing and fulling.

Upon Silk by Printing.—Anotta dissolved in soft soap or potash: or berries, cochineal, and tin salts.

Upon Silk by Dyeing.—Anotta is the chief source of orange upon silk. Finished in weak acids, it has a red, orange, or aurora shade; by mixture with yellow from bark and tin, all the shades of salmon, straw, gold, etc. are obtained. Safflower and cochineal are employed as red modifiers; while galls turn the shades from anotta towards nankeen.

BLUE AND YELLOW MIXED COLOURS.

Greens and olives alone are produced of this class. With the exception of the Chinese green colouring matter and some chrome and copper shades, they are all made by mixture of blue and yellow in different proportions.

Upon Cotton by Printing.—All the usual topical greens are direct mixtures of blue and yellow; the blue being Prussian blue, the yellow being from berries, bark, or fustic, with tin or alumina mordants. Grey greens are obtained from salts of chromium, fixed by lime or soda. Shades of olive are usually from the same materials as green, but occasionally logwood is used for the blue part. Arsenite of copper greens are printed with a salt of copper, fixed in lime and raised in arsenious acid. Solution of soaps of copper in turpentine have been employed. The application of chrome or other yellows upon indigo blue produces tolerably fast but dull greens. There is a pigment green from oxide of chromium.

Upon Cotton by Dyeing.—The fastest greens are upon an indigo basis, the yellow being from bark or fustic, with alum as a mordant: other greens have a chrome yellow and some a Prussian blue basis. Common greens, from which the blue part washes out, are made from fustic and an aluminous basis, and padded in sulphate of indigo. Dark olive green is obtained upon a Prussian blue basis by the use of acetate of alumina, fustic, and sumac, with acetate of iron to sadden the shade.

Upon Wool by Printing.—The yellow part is derived from berries, turmeric, or bark, with tin salts, and the blue from sulphate of indigo with addition of tartaric acid.

Upon Wool by Dyeing.—Best colours have a basis of fast blue by dipping, with fustic upon an aluminous mordant for the yellow; but usually the yellow is dyed first, and the blue part consists of sulphate of

indigo. Logwood is also employed for the darker shades, with small quantities of sulphate of iron and copper. Ordinary greens are prepared from logwood and fustic only, the wool being prepared by bichromate of potash and alum. Other yellow colouring matters may be employed, as weld, dyer's broom, etc.

Upon Silk by Printing.—The blue part is sulphate of indigo, the yellow from Persian berries or turmeric and tin salts; for darker greens, fustic with alum and copperas may be employed instead of berries.

Upon Silk by Dyeing.—The same materials are used as in printing, viz.,—sulphate of indigo for the blue part, and berries or turmeric for the yellow. For the deeper or olive shades, anotta and logwood are used

MIXED COLOURS FROM RED, BLUE, AND YELLOW.

These include an infinite variety of shades depending upon the relative proportions of the primary colours. The colour produced by an equally balanced mixture of them is brown or chocolate or black in the concentrated state; by dilution the chief shades obtained are drab, grey, and chestnut; while, by the predominance of one or other of the primary colours, a multitude of mixed shades may be produced, which having no well established names cannot be described without illustration. It is not possible to indicate more than a few of the most characteristic of these colours, but the instances are sufficient to give an idea of the method of obtaining all the allied colours.

Upon Cotton by Printing.—Browns and chocolates for topical application are chiefly composed of red from peach or sapan wood, yellow from bark or fustic, and blue from logwood; or simply a mixture of steam green with peachwood and alum, the blue in this case being obtained from the prussiate; oxidising substances are added for the sake of the woods, such as nitrate of copper and chlorate of potash. Lighter shades may be made from berries or sumac, with peachwood, logwood, and alum, or mixtures of steam orange with logwood and copper salts. In the composition of chocolates the peachwood influences the redness, the logwood communicates the purple tone, and bark the yellow; if any of the prussiates are used they give the blueness. From this knowledge, and employing a proper portion of mordant, the shade may be varied at pleasure. Manganese, peroxide of lead, and sulphuret of antimony, have been used for brown, bronze, and chocolate shades. Grey colours are obtained from logwood with alum, iron and copper salts, or from bark with

mixed iron and alumina mordants. Greys of a lavender or pearl shade contain more or less blue, partly derived from logwood, partly from the prussiates. Drabs, like greys, are obtained from bark with iron and copper salts. Similar shades may be also obtained from mixtures of manganese and chromium salts, by fixing in lime. Catechu may also be used to obtain a great variety of shades of brown, drab, wood, fawn, etc.

On Cotton by Dyeing.—The same materials are used as in printing, in most cases; the yellow, red, and blue or purple woods combined together with an aluminous basis. Anotta is used in some cases; sumac very frequently, along with copperas. Catechu, fixed by bichromate of potash, gives good shades of chocolate and fawn, and when combined with logwood darker shades; catechu, with sulphate of iron, modified by alkali or soap, is also used for the less dense colours. In some styles a basis of blue, either indigo or Prussian, with a superimposed purple from logwood and alum, is employed for dark shades. Drab and grey are only modifications and degradations of brown and chocolate, and are obtained in similar ways.

Garancine Chocolate.—The most usual chocolate in calico printing is obtained from garancine, mixed with peachwood, sumac, and bark; the mordant is a mixture of red and iron liquors, in proportions fixed with reference to the shade of chocolate desired. Garancine, without admixture of woods, could not yield the deep shades of colour required in the market; the colouring matter of the woods fills up the garancine colour. If woods are used in moderate proportion, the stability of the colour is not much affected, but their cheapness sometimes causes them to be too largely employed, and the resulting colours fade and wash out. Pure garancine gives colours not much differing from madder. From a series of experiments made upon the influence which size and the woods have upon the garancine colours, I obtained the following results:—

Size preserves the whites; which it does by forming a compound with the tannin matter of the sumac. This compound is insoluble in water, cannot fix upon unmordanted fibre, but near the boiling point is decomposed when in the presence of mordants and combines with them, the gelatine becoming free again.

Peachwood darkens the chocolates, making them fuller, heightens the red, and, if purples be present, fills them up. The chocolate obtained with garancine alone is red; the addition of peachwood makes it fuller and heavier. When bark and sumac are used, without peachwood, the reds suffer in brightness, and the chocolate tends towards a cold clayey aspect; if bark and sumac are used, with a double portion of peachwood,

the chocolate is darker, but suffers in brightness, the reds remaining about the same. The chief action of peachwood is, therefore, to fill up the garancine shades, the colours it yields not being much different from the garancine colours themselves.

Quercitron Bark itself gives yellow colours with alumina mordants; drab with weak iron; and greenish olive with chocolate mordants. Garancine and it together differ from garancine alone, by a yellowish shade over the chocolate, taking it to the clayey side; the reds are made decidedly orange, and the purples turned greyish. When peachwood and sumac are used, without the bark, the chocolate is deficient in brightness: it has a purplish cast, and looks heavy and flat; the reds also want more fire and brilliancy. If a double quantity of bark be employed, the chocolate turns to the clayey shade, and the reds look weak. All this time the black is not much affected, the garancine itself appearing to have a strong possession of that colour.

Sumac is the general darkener of all the colours; it improves the reds, chocolates, and blacks, but destroys lilacs or purples if they should happen to be in the piece. Without sumac, and with peachwood and bark, the reds would be dull and heavy, and the chocolate not black enough. It partially fills the place of bark by its yellow colouring matter, but that is insignificant when compared with its action upon the iron mordants, to which it communicates dark shades, giving depth and apparent solidity to the whole; upon the red it has not much influence; it turns it a little towards the orange, and thus brightens it.

Garancine Dyeing is conducted in the same way as madder dyeing, and the same general remarks are applicable, without much modification. A higher temperature can be used with advantage, as there is less fear of injuring the whites, and it is customary to carry the dye to the boil for a few minutes at the conclusion. Less than two hours will not exhaust the colouring matter, nor give good work as a general rule. After dyeing, the clearing is accomplished in various ways; sometimes a hot watering, and clearing with bleaching powder; sometimes a passage in bran; and, in France, it is often usual to boil with cow dung for twenty minutes; hot watering is not thought necessary in most places, and is liable to injure the colour. The pieces, after a good washing, are padded in chemic and steamed in a box, then well washed and finished, with a rather heavy dose of blue. The woods have a great deal to do in producing the colour, and their good quality is a matter of importance. The sumac seems to be the one most likely to be wrong, and to throw the other colours bad, therefore particular attention should be paid to its quality. The woods may be used in various proportions, according as the

shade may be desired of one kind or another ; but I believe the best results, for general purposes, are from equal weights of each. Too much garancine can spoil the shades, as well as too little ; the garancine is the strongest colouring matter, and, if it be in excess, it will fill the mordants to the exclusion, in a great measure, of the other colouring matters present, and, of course, not give the same shades. I made experiments as to the utility of adding the woods at different times to the dye, both before and after the garancine was in, and also dyed up pieces in the garancine alone, and then in the woods, and *vice versa*, but I obtained no better results than were to be obtained by simply adding all at once, and dyeing up together ; sometimes the difference was decidedly on the wrong side. Garancine is very susceptible to the action of chemical matters in the water, and, on the whole, seems to require a purer water than madder to give the best results. Additions of various chemical salts are, for the most part, detrimental ; few can be employed with impunity, and none that I know of with advantage, except those which neutralise the acid, and a very small excess of these is injurious.

Mr. J. Graham discovered that steaming garancine work, at a high pressure, gave stability to the colours, and a power to resist the action of deterative substances, which they did not previously possess. I made some experiments upon this matter, and found some remarkable results in that direction ; but this discovery did not appear to me practically useful, for I found that the shades were injured, and could not be easily restored to their goodness. To make colours more permanent is, of course, one of the highest aims of a printer and dyer ; but not the smallest amount of brilliancy can be spared for that purpose.

Upon Wool by Printing.—Archil, with tartaric acid and a little alum, and sulphate of indigo, gives rich shades of chocolate ; other colouring matters are mixed with archil, as fustic, logwood, and sapanwood, with alum and tin. Peachwood, mixed with bichromate of potash, alum, acetate of copper, and sulphate of indigo, gives a chocolate. Colours can also be obtained from cochineal for red, bark for yellow, and sulphate of indigo for blue. From catechu, mixed with sulphate of indigo and other woods, a great variety of mixed shades may be produced.

Upon Wool by Dyeing.—Dark browns and chocolates are obtained from mixtures of the three primary colours in a variety of methods ; fustic, madder, peachwood, and logwood, give a deep colour with an iron mordant. Cudbear and archil alone, or mixed with logwood and peachwood, with an iron mordant, or with a mixed iron and alumina mordant, yield shades of brown and puce. Gallnuts and sumac are sometimes

used as colouring matters, and bichromate of potash as mordant. The reduced shades of drab, slate, grey, etc., can be produced by weaker baths and different proportions of materials; peachwood, logwood, fustic, and sulphate of indigo, serving to produce most of the shades required.

Upon Silk by Printing.—Mixture of logwood, peachwood, and bark or berries, with alum, produces chocolates; salts of copper and tin may be added. Grey is obtained from dilute logwood and nitrate of iron; other shades of grey from a mixture of blue and red with a little yellow.

Upon Silk by Dyeing.—Archil alone gives a bronze brown; the compounded colours, as before-mentioned, are from fustic, peachwood, and logwood. Anotta is sometimes used as an orange basis, upon which fustic and peachwood with copperas give the brown, or logwood and tin salts. Peachwood and logwood, with alum, give chocolate; addition of fustic or bark makes a brown. Drabs, greys, and stone colours, are mostly derived from fustic for the yellow, and archil for the red and blue parts; sumac, with iron salts, also gives similar shades.

WHITES.—RESISTS.—DISCHARGES.

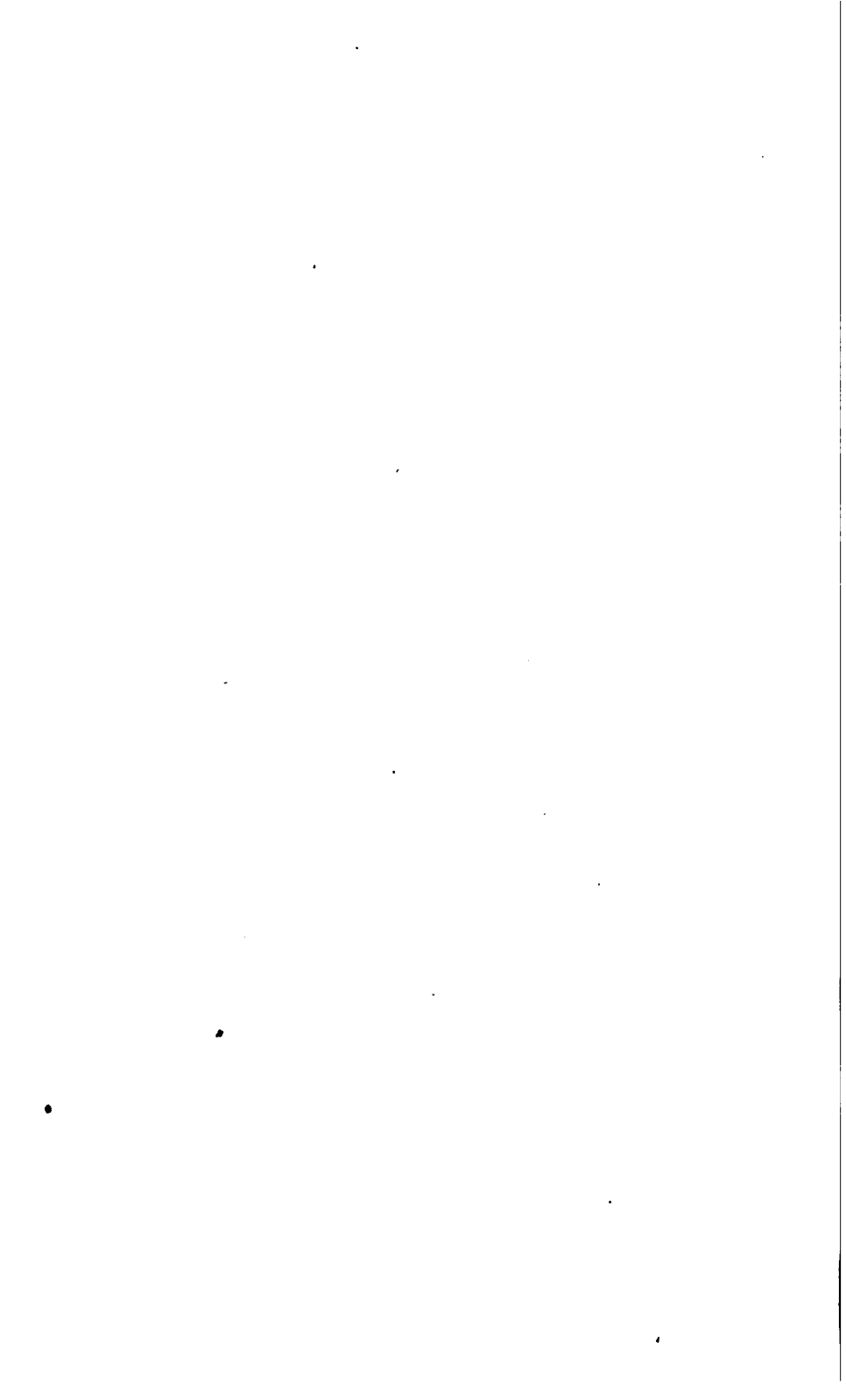
The only usual white upon printed goods is that of the fabric itself, but a topical white is sometimes employed. The best consists of oxide of zinc, fixed by means of albumen. I have seen white lead, fixed by drying oils, but it looks too much like paint. Whites are obtained upon dyed grounds, either by *resisting* the fixation of the colour, or by *discharging* it from the spot. Resists are either mechanical or chemical, or both combined. The first reserved white spots in Indian dyeing were obtained by tying up portions of cloth with string; peculiar effects are obtained by the same process at this day for the African markets; the dye does not penetrate to the tied portions, and they are consequently left white. The next resist, in point of date and the type of a mechanical resist, was bees' wax, which being melted into parts of the cloth, preserved those parts from actual contact with the dyeing fluid. The chief mechanical resisting agents in use now are gum water, pipe clay, China clay, sulphate of lead, and similar insoluble salts. The chemical resists are mostly of an acid nature when mordants alone are to be resisted, but of a more complex nature when colours have to be resisted; the only usual case of which is in indigo dyeing. The chief resists are—for iron and alumina mordants, citric acid or lime juice; for indigo blue dipping, mixtures of pipe clay, sulphate of copper, soap, sulphate of manganese, sulphate of lead, sulphate of zinc, glue, and other thickenings

combined according to the style of work, much care being necessary to reserve a good white upon dark grounds. Resist paste, for dyed colours, is generally mechanical, being pipe clay, sometimes with a mixture of citrate or arseniate of soda or potash; resist for China blue contains nitrate of copper, sulphate of lead, and lime juice; half resist, for steam colours, may be simply thick gum water, or bioxalate of soda; crystals of tin, mixed with red liquor, resist weak iron mordants; citrate of soda may be used in many cases where the acidity of citric acid would be objectionable. The object to be attained in a resist is to paralyse the chemical activity of the mordant or colour, or to offer it a surface to deposit upon, which may be subsequently detached by washing. The chemical resists effect the first point, and the mechanical resists the second.

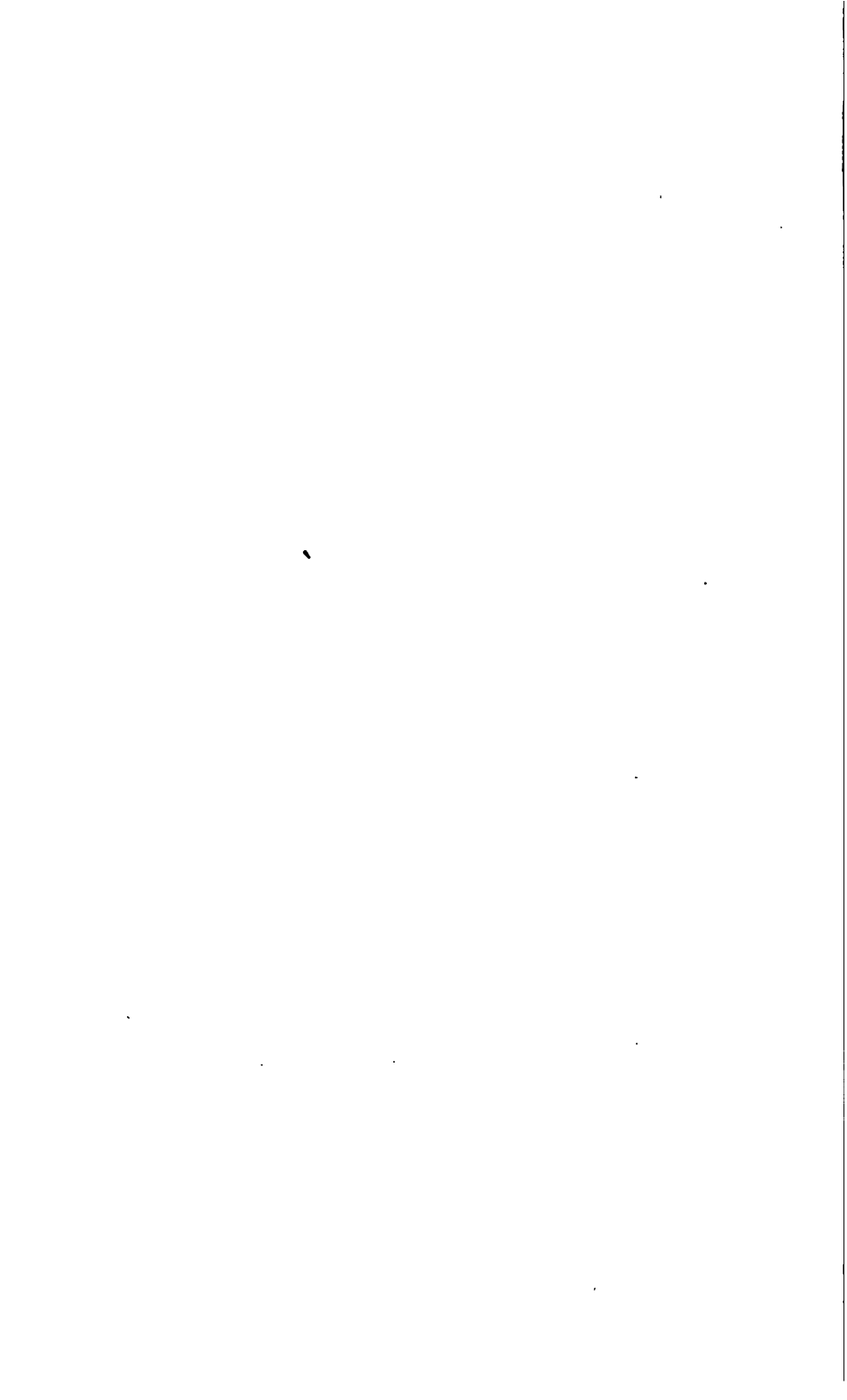
Discharging is employed to produce designs upon grounds uniformly coloured, generally to produce a white by the destruction of the colour, and sometimes to substitute a fresh colour. The chief cases are as follows:—chloride of tin, with a little acid, discharges nearly all the mineral colours, as iron buff, manganese brown, lead puce, etc.; indigo blue is discharged by the combined action of bichromate of potash and an acid, usually oxalic acid, the cloth is padded in the bichromate and the acid printed on; the red prussiate of potash, with caustic potash or magnesia may be also used; Turkey red and madder purple are discharged by the agency of chlorine; in the bandana style solution of chlorine or chloride of lime is applied by the press and perforated plates, as is well known; another method consists in printing an acid (usually tartaric) and passing through strong chloride of lime, containing an excess of lime,—the chlorine liberated discharges the colour upon the printed spot, while the excess of lime prevents a too extended action of the acid. By mixing lead salts with the tartaric acid, and subsequently passing in chrome, orange is obtained; and blue and green by mixtures of Prussian blue and lead salts. Prussian blue dyed grounds are discharged by caustic alkalies. As a general rule, the whites obtained by resisting are better than those by discharging.

Finishing of Dyed Goods.—The drying, stiffening, blueing, mangling, etc. of goods, after the colours have been imparted to them, do not involve the application of any special chemical principles: these operations, though of the highest importance, are so entirely mechanical as not to come within the scope of this work.





ADDENDA.



REFERENCES

TO ENGLISH AND FOREIGN JOURNALS AND MAGAZINES CONTAINING
ARTICLES IN CONNECTION WITH THE SUBJECT OF THIS WORK.

THE ABBREVIATIONS USED ARE:—

- Ann. de Ch.—*Annales de Chimie*. Paris.
Ann. de Ch. et Ph.—*Annales de Chimie et de Physique* (a continuation of the *Annales de Chimie*). Paris.
Bull. de Mulh.—*Bulletin de la Société Industrielle de Mulhouse*.
Techn.—*Le Technologiste ou Archives de progrès, etc.* Paris.
Chem. Gaz.—*Chemical Gazette or Journal of Practical Chemistry* (now *Chemical Times*). London.
Rep. de Ch.—*Répertoire de Chimie pure et appliquée*. Paris.
and a few others of an evident nature.

A.

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OF WORKS WHOLLY DEVOTED TO DYEING, ETC.,
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- Parnell, E. A. *Dyeing and Calico Printing.* London, 1849.
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PATENTS

GRANTED UPON SUBJECTS CONNECTED WITH DYEING, PRINTING, AND
BLEACHING, FROM DEC. 31ST, 1857, TO DEC. 31ST, 1859.

The Commissioners of Patents having recently issued abridgments of all the patents connected with these matters, for the period prior to 1st January, 1858, the author has made no reference to them, since that publication is indispensable to all who seek a complete knowledge upon the improvements in these arts.

1858—January 29th. No. 167. J. GOODWIN : *Preparation and Cleansing of Textile Fabrics, etc.*—Invention relating to a patent granted previously to the same party. "By boiling coal, cinders, or other carbonaceous matter in water, adding a portion of chalk," etc., the patentee claims to obtain a liquor suitable for cleansing dyed goods, and which may act also as a dung substitute. *This patent was abandoned.*

1858—February 12th. No. 265. W. N. WILSON : *Improvement in Washing and Wringing Machines.*—*This patent was abandoned.*

1858—March 8th. No. 468. J. H. JOHNSON : *Ornamenting Leather Cloth and similar Fabrics, etc.*—Refers to the use of an oil basis or mordant, upon which leaves of gold and silver are fixed, and afterwards varnished and pressed.

1858—March 11th. No. 493. F. A. VERDEIL : *Improvements in Treating Madder.*—Refers partially to a previous patent, upon which it is an improvement. The madder is extracted by weak caustic soda, and precipitated by sulphuric acid; the product so obtained is fit for dyeing with. By boiling this product with sulphuric acid another is obtained, which can be used for garancine dyeing. The first precipitate, according to a previous patent, was dissolved in alcohol or wood spirit for printing purposes.

1858—March 12. No. 497. J. WORRAL and C. RACE : *Machinery for Stretching and Drying Fabrics.*

- 1858—March 27. No. 648. R. WILLIAMS : *Soap for Cleansing and Bleaching Purposes*.—A complicated and absurd receipt for producing a mixture of soap and fuller's earth. *This patent was abandoned.*
- 1858—March 31. No. 679. F. A. GATTY : *Treating Compounds containing the Colouring Matter of Madder*.—The object is to purify the compound of an earthy soap and the colouring matter of madder from impurities; this is said to be accomplished by dissolving the compound in carbonate of soda, precipitating by an excess of acid, and re-dissolving the precipitated matter in dilute ammonia.
- 1858—April 7th. No. 748. W. NIMMO : *Printed Woven Fabrics*.—The novelty consists in the weaving; not in the printing.
- 1858—April 12th. No. 789. T. KAY : *Obtaining Heat for Singeing Yarns and Textile Fabric*.—The heat is obtained from gas, by causing it to mix with atmospheric air, so as to burn without deposition of carbon.
- 1858—April 14th. No. 809. MATHER & CHARLTON : *Apparatus for Drying Cotton, Linen, Wool, etc.*
- 1858—April 14th. No. 812. J. KNIGHT : *Machinery for Scouring, Washing, and Cleansing Textile Fabrics*.
- 1858—May 1st. No. 977. W. SPENCE : *Purple Colouring Matter called French Purple*.—The specification is incomprehensible, and apparently meant to give no information for the protection. The colouring matters are the lichens, which yield archil; the point in the process consists in keeping the solution for a length of time in shallow vessels at 140° F., and exposed to the air. The altered product gives much faster colours than ordinary archil.
- 1858—May 3rd. No. 981. J. A. HARTMANN : *Preparing and Combining Colours for Printing*.—A steam madder purple, made by dissolving some extract of madder, not specified, in acetic acid, and then mixing with iron liquor. The colours may be brightened by passing in a soap or alkaline bath.
- 1858—May 6th. No. 1,015. J. WRIGHT : *Treating Madder for Printing and Dyeing*.—Madder is treated with water, or bran water, and pressed; the gelatinous fluid subject to various treatments with water and dilute acid, and the residue forms an extract for printing or dyeing with. In dunging for the dye the patentee filters the dung liquor to get rid of the obnoxious colouring matter.
- 1858—May 11th. No. 1,051. J. H. JOHNSON : *Improvements in Madder Dyeing*.—The improvement consists in the addition of about a pint of ammonia to every 10lb of madder or garancine used

in the dye ; from three to five minutes in the decoction suffices to dye ; about a pint of alcohol added keeps the whites clear. *This patent was abandoned.*

- 1858—May 11th. No. 1,053. J. SOUTTER : *Improvements in Washing Machines.*
- 1858—May 17th. No. 1,101. H. CURZON : *In Preparing Printed Yarns.*—The improvement consists in the steaming ; instead of the cut straw or hulls formerly used to keep the condensed water from penetrating to the yarns, he uses coarse woollen or cotton cloth.
- 1858—May 18th. No. 1,106. J. MALLINSON : *Improvements in Dyeing Yarns.*—The yarns are to be dyed in a vacuum, instead of in the usual way. *This patent was abandoned.*
- 1858—May 20th. No. 1,123. M. BRUN : *Improvements in Dyeing.*—The novelty here consists in using a mixture of the ordinary dye spirits with sulphuric acid, or sulphate of zinc, in piece dyeing. Such a mixture is said to give better, cheaper, and faster colours ; it is mixed with colouring matter, or applied after it.
- 1858—May 26. No. 1,174. F. A. GATTY : *Treating Cotton Fabrics after Dyeing.*—This refers to madder reds, which the patentee treats with acids or acid salts, preferring alum, but using also hydrochloric acid. The goods are impregnated with the acid solution, “whizzed” or “squeezed,” and then heated from 180° to 212° F. for about an hour, by which the colours are brightened.
- 1858—May 29th. No. 1,217. M. HENRY (a communication) : *Improvements, etc., in Dyeing.*—This patent includes tanning, and the making of pasteboard and blacking ; the novelty seems to consist in the treating of certain vegetable substances with chlorine and acids before using them for dyeing. With regard to silk dyeing, it is claimed that the fabric takes the dye better, and gains in grain and appearance.
- 1858—May 31st. No. 1,221. J. GIRERD & ANOTHER : *Improvements in Ornamenting, Staining, etc.*—Producing designs by pressure from models, etc., and obtaining shades by optical effects. *This patent was abandoned.*
- 1858—May 31st. No. 1,224. H. JAEGER : *In Dyeing Wool.*—Refers to dyeing wools with murexide ; the novelty consists in boiling the wool, previous to dyeing, in dilute acids. *This patent was abandoned.*
- 1858—May 31st. No. 1,225. W. E. NEWTON : *Printing and Dyeing Textile Fabrics.*—Relates to the modification in the construction of machinery. *This patent was abandoned.*

- 1858—June 8th. No. 1,285. J. M. DUNLOP: *Bowls or Rollers for Printing*.—Application of vulcanised indiarubber as lapping, etc.
- 1858—June 9th. No. 1,297. F. A. GATTY: *Dyeing Cotton and other Materials*.—The patentee takes the soap liquors in which madder goods have been cleared, especially Turkey reds, and precipitates, by an excess of acid, and uses the precipitate as a dyeing material. Refers to patent of March 31st, 1858, upon which it is an improvement or simplification.
- 1858—June 19th. No. 1,383. S. HEWITT: *Printing Designs on Cotton and other Fabrics*.—With the object of producing, by printing and dyeing, goods to represent woven materials.
- 1858—June 22nd. No. 1,407. W. & J. GALLOWAY: *Machinery for Cutting, Bruising, Chipping, Rasping, etc., Dyewoods*.
- 1858—June 23rd. No. 1,414. S. BARLOW: *Machinery for Bleaching or Cleansing Textile Fabrics*.
- 1858—June 23rd. No. 1,421. RUMNEY & OTHERS: *In Dyeing and Printing Cotton Wool, Silk, etc.*—Refers to murexide colours and the use of metals in alkaline solution, as carbonate of lead in soda plumbate of soda, etc., in the way of a prepare. *This patent was abandoned.*
- 1858—June 30th. No. 1,474. J. PETRIE: *Machinery or Apparatus for Drying Warps of Yarn on Thread and Woven Fabrics*.
- 1858—July 2nd. No. 1,484. J. MORRIS: *Rollers or Cylinders for Printing*.—With a view to the use of thin copper shells. *This patent was abandoned.*
- 1858—July 7th. No. 1,524. W. CLISSOLD: *Machinery for Cutting or Rasping Dyewoods*.
- 1858—July 8th. No. 1,544. G. SAMPSON: *Finishing of Woven Fabrics*.—Consists in mechanical contrivances to prevent the steam wetting the fabric. *This patent was abandoned.*
- 1858—July 16th. No. 1,603. T. LEIGH: *Machinery for Sizing Warps*.
- 1858—July 26th. No. 1,677. J. COOKE: *Singeing, Treating, or Finishing Textile Fabrics*.—The singeing is performed by means of gas and air, and the details involve several mechanical changes.
- 1858—July 28th. No. 1697. A. KELLERMAN: *New Substances for Dyeing to Replace Cochineal*.—The new colouring matters are the flowers and leaves of the elm (aulnès). The flowers producing a red and green colour, and the leaves a yellow colour. No information as to the mordants to be employed or manner of application.

- 1858—August 2nd. No. 1,745. R. R. JACKSON: *Machinery for Sizing Yarn. This patent was abandoned.*
- 1858—August 9th. No. 1,816. W. SPENCE: *Precipitation of Purple Colouring Matter.* The purification of archil colour, by adding solution of chloride of calcium to the ammoniacal solution of the archil, the violet or purple colouring matter is precipitated in combination with lime, while the red colouring matter remains in solution. Refers also to a patent of May 1st, 1858, for French purple.
- 1858—August 13th. No. 1,845. W. B. NORTCLIFFE: *Improvement in Dyeing Woollen, Worsted, Cotton, etc.*—Chiefly applicable to dyeing black on woollen goods in two vats. Number one vat contains extracts of logwood and fustic (or other yellow colouring matter), and sometimes catechu along with nitrate of copper; when the materials have been sufficiently long in this vat they are taken to vat number two, which is composed of a solution of chromate of potash, and for some shades a little sulphate of copper.
- 1858—August 14th. No. 1,860. LISTER & WARBURTON: *Dyeing Wool, Hair, Cotton, etc.* The improvements consist in dyeing the various materials in vacuum, with or without the addition of heat and suitable motion.
- 1858—August 14th. No. 1,864. L. A. FOROT: *Ornamenting Fabrics.* Relates to a method of glueing shreds of silk or other fibres upon paper, muslin, etc., from which they can, when dry, be separated by a knife.
- 1858—August 30th. No. 1,959. BRAZIL & Mc.KINNEL: *Improved Method of Indigo Blue Dyeing* (a communication). The improvement consists in dipping two pieces of cloth into the vat, so that the face side of each only is freely exposed to the action of the air and dye, and the backs but little dyed.
- 1858—August 30th. No. 1,961. BRAZIL & Mc.KINNEL: *Improved Method of Indigo Blue Dyeing.*—The novelty here consists in the ancient method of padding the piece on one side in a solution of salt of manganese, so as to cause that side to attract more colour than the other when dipped in the ordinary vat.
- 1858—August 30th. No. 1,962. B. HANSON: *Apparatus for Sizing and Drying Woollen Yarns for Warps. This patent was abandoned.*
- 1858—September 9th, No. 2,049. W. CLARK (communication from Kuhlmann): *Materials for Dyeing.*—For the introduction of chromates, tartrates, oxalates, etc., of barium, for dyeing pur-

- poses, and for the addition of an equivalent of hydrochloric acid to bitartrate of potash to double its power. *This patent was abandoned.*
- 1858—September 13th. No. 2,071. W. THOMSON : *Bleaching Yarn, Warps, etc.*—The patentee passes the warps, etc., before sizing them, through a weak solution of chloride of lime or chloride of soda, then over hot cylinders or a steam chest, where the bleaching is effected, and then through rollers to wash off the remains of the bleaching agent.
- 1858—September 22nd. No. 2,125. J. JOHNSON : *Apparatus for Washing, Churning, Colour Mixing, etc.*—Something like a domestic peggy. *This patent was abandoned.*
- 1858—September 22nd. No. 2,127. J. HOPE : *Rollers or Cylinders for Calico Printing.*
- 1858—October 14th. No. 2,299. J. LOMAS : *Ornamenting Fabrics.*—Relates to the production of designs by embossing on printed or other goods. *This patent was abandoned.*
- 1858—October 16th. No. 2,315. A. ROBERTSON : *Applying Starch and similar matters.*—The starch, etc. is applied by means of a roller covered with a film of it, and moving in contact with the fabric but at a slower rate. *This patent was abandoned.*
- 1858—October 16th. No. 2,316. A. DUNN : *Marking Compounds for Linen and other Fabrics.*—Nitrate of silver is mixed up with wax, stearine, plumbago, and vermilion, to form a hard pencil, which is the marking compound. The fabric to be marked is moistened, preferably with a solution of tartrate of potash, and written upon with the pencil, the colour being afterwards developed by a hot iron.
- 1858—October 29th. No. 2,423. J. MORRIS : *Rollers or Cylinder for Calico Printing.*
- 1858—November 3rd. No. 2,456. P. A. MAWDSLEY : *Apparatus for Drying Yarns, and the use of a certain substance, etc.*—The patentee only claims the use of soluble aluminates of potash or soda for the purpose of stiffening.
- 1858—November 4th. No. 2,465. C. MATHER : *Drying Yarns in the hank.*—*This patent was abandoned.*
- 1858—November 4th. No. 2,466. W. T. MABLEY : *Printing and Dyeing Woven Fabrics.*—Refers to the dunging process, and proposes the addition of several saccharine substances to the usual substitutes.—*This patent was abandoned.*
- 1858—November 5th. No. 2,475. D. MC. CLURE : *Drying Yarn, Thread, Cloth, etc.*—*This patent was abandoned.*

- 1858—November 13th. No. 2,557. M. PULLAN : *Drying Yarns and other materials.*
- 1858—November 17th. No. 2,579. F. A. GATTY : *Certain Colours on Cotton, Linen, and Silk.*—Refers to obtaining madder red and pinks by topical application and steaming. An extract or solution of madder or garancine is obtained by boiling these matters with concentrated acetic acid ; when the solution is sufficiently strong, it is mixed with acetate of alumina or red liquor and gum water, printed, steamed, and washed in the usual way. The colours may be brightened by a passage in boiling soap.
- 1858—November 25th. No. 2,682. W. BURTON : *Colouring matter for Dyeing.*—The colouring matter is obtained by treating dry extract of archil with naphtha, alcohol, ether, or chloroform, and using oxalic acid and ammonia in the dyeing.—*This patent was abandoned.*
- 1858—November 27th. No. 2,698. R. ALEXANDER : *Preparing and Bleaching Textile Fabrics.*—A method of exposing them open to the direct action of steam instead of boiling them in liquids.
- 1858—December 1st. No. 2,741. C. F. VASSEROT : *Colouring Threads, etc.*—This invention is a mechanical contrivance for printing or staining threads when being unwound from bobbins, etc.—*This patent was abandoned.*
- 1858—December 3rd. No. 2,767. C. COATES : *Mandrils for Printing.*—*This patent was abandoned.*
- 1858—December 4th. No. 2,782. J. L. NORTON : *Machines for Stretching and Drying Fabrics.*—*This patent was abandoned.*
- 1858—December 7th. No. 2,800. WHITELEY & KITCHENMAN : *Hot-pressing Woven Fabrics.*—*This patent was abandoned.*
- 1858—December 10th. No. 2,883. J. LIGHTFOOT : *Printing and Staining Yarns and Fabrics.*—Refers to the use and application of alkaline solutions of mordants and colouring matters fixed by subsequent processes.
- 1858—December 15th. No. 2,867. J. PENDLEBURY : *Machinery for Bleaching and Cleansing Textile Fabrics.*—Using liquids boiling under pressure and a temperature exceeding 212° Fahr.
- 1858—December 18th. No. 2,904. E. WEBER : *Improvements in Dyeing or Colouring Textile Fabrics.*—These improvements consist in forcing the dyeing liquids through the materials to be dyed whilst they remain at rest.
- 1858—December 21st. No. 2,915. BOLTON & GARFORTH : *Drying Yarns or Fabrics.*—*This patent was abandoned.*
- 1858—December 24th. No. 2,942. J. W. CHILD : *Dyeing Wool and*

other Fibres.—Mechanical apparatus for dyeing in a continuous length of thread, instead of in hanks or coils.

1858—December 28th. No. 2,969. J. LECK : *Drying Textile Fabrics.*

1858—December 29th. No. 2,976. R. D. KAY : *Colouring matters from Tar.*—Claims the use of mixtures of the colouring matters from aniline with albumen, protein, caseine, lactarine, and other similar substances.

1858—December 29th. No. 2,979. S. MORAND : *Stretching Fabrics.*—*This patent was abandoned.*

1858—December 30th. No. 2,989. R. A. BROOMAN (communication from S. Charles, Paris) : *Washing and Drying Machinery and Apparatus.*

1859—January 1st. No. 11. R. SMITH : *Castings applicable to Printing Surfaces, etc.*—A plan of casting stereotype plates. *This patent was abandoned.*

1859—January 5th. No. 38. W. DRAPER : *Printing on Paper and other Fabrics.*—New methods of carrying the blocks and feeding them with colour.

1859—January 5th. No. 40. RUMNEY AND MC.DONALD : *Printing and Dyeing Fabrics.*—Chiefly with reference to murexide, and consists of a double mordanting ; first in an acid solution, and secondly in an alkaline solution of the mordanting base, and the use of acetates with arsenious acid, and, lastly, the use of acetate or sub-acetate of lead.

1859—January 6th. No. 47. W. RENTON & OTHERS : *Finishing Woollen and Other Fabrics.*—The goods are subjected, in a vessel heated to 200° Fahr., to hydraulic pressure of 500 or 600 pounds to the square inch.

1859—January 11th. No. 88. VERSMAN & OPPENHEIM : *Rendering Fabrics Non-Inflammable.*—By steeping in solution of sulphate of ammonia, or putting this salt in the starch or size used to finish the fabric. A very old method.

1859—January 17th. No. 135. W. MORGAN : *Printing and Stenciling.*—*This patent was abandoned.*

1859—January 20th. No. 175. GREENWOOD & BATLEY : *Process of Gassing Fabrics.*—The invention is to prevent decoloration by the deposition of carbon ; they use the ordinary burner, but cause the flame to be directed *horizontally* against the fabric passing *vertically*,

by which a supply of air is always kept between the flame and fabric.

1859—January 20th. No. 182. SAGAR & SCHULTZ: *Producing Pink Shades on Fabrics*.—A murexide pink, made by dissolving murexide in nitrate of lead, and adding bi-chloride of mercury. The yarns, etc., are padded in this mixture, and the shade modified and “fixed” by passing them through some thickening material, containing a suitable acid or alkaline salt.

1859—February 5th. No. 332. GREENHALGH & OTHERS: *Treating and Preparing Yarns or Threads Previous to Dying*.—The object of this invention is to treat yarn in the “cop,” so as to make it able to take up colours as well as woollen. This is accomplished, according to the patentees, by saturating the “cops” with sumac or catechu, and then with a solution of iron. Such cotton can be woven with woollen and dyed with it, taking the same shades.

1859—February 5th. No. 337. BOOTH & FARMER: *Sizing and Stiffening Woven Fabrics*.—The idea is to let the size touch only one side, or a portion of the goods to be finished. The method is very inefficient. *This patent was abandoned.*

1859—February 7th. No. 339. J. HOLROYD: *Finishing Woollen and other Cloths*.—The novelty consists in interposing a sheet of thin brass between the cloth and the card cylinder used for turning back the nap of woollen and other cloths so as to produce a pattern. *This patent was abandoned.*

1859—February 9th. No. 365. J. CROSSLEY: *Steaming Printed Yarns*. The improvements consist in methods of preventing the condensation of water upon the zinc plates used by the patentee to separate different lots of yarns, and thus prevent stains caused by the drops; and also to passing steam through the yarns, supported on the cradle, directly from a trough of water placed beneath.

1859—February 12th. No. 403. G. T. BOUSFIELD: *Revivifying the Scarlet Colour of Woollen Cloth, etc.*—The patentee prescribes a mixture of 300 grs. citric acid, and 150 grs. carbonate of potash, with 7,500 grs. water, to be applied to the cloth to be revived. Other acids and acid salts have the same effect. *This patent was abandoned.*

1859—February 12. No. 405. R. BELL: *Separating Wool from Cotton, etc., in Mixed Fabrics*.—The patentee steeps the fabric in solution of the impure chloride of manganese, resulting from the manufacture of chlorine, wrings them out, dries them in a stove, and separates the disorganised cotton by the usual mechanical means.

- 1859—February 16th. No. 440. J. EASON: *Apparatus for Tanning, Dyeing, and Extracting Vegetable Matters, etc.*—Extraction “by exhaustion and repletion, caused by hydraulic and hydrostatic pressure” in large tanks, capable of sustaining a pressure of 1,000 pounds to the square inch.
- 1859—February 22. No. 486. R. A. BROOMAN (M. Verguin, France): *Fixing Tannin upon Textile Fibres, and Dyeing Black and Dark Colours.*—The material is steeped all night in the astringent matter cashoo (catechu?); then passed in weak muriate of tin, by which it is fixed. For obtaining blacks he operates upon a Prussian blue basis first, and finishes by dyeing as usual in red woods and iron salts.
- 1859—March 1st. No. 538. J. HOLROYD: *Finishing Woollen Cloths and other Cloths*—The invention consists in cutting the nap shorter on certain parts, producing peculiar effects. *This patent was abandoned.*
- 1859—March 2nd. No. 560. H. BROWN: *Cutting and Finishing the Surfaces of Woollen and other Fabrics.*—An arrangement by which certain parts are left uncut, so as to produce furrows, etc. *This patent was abandoned.*
- 1859—March 5th. No. 585. VERDEIL & MICHEL: *Treating Madder.*—The madder is mixed with milk of lime, then exposed to the air for twenty four hours in an effectual manner, and then made into garancine, which is said to be much stronger and better than without the use of lime. Other alkalies may also be used besides lime.
- 1859—March 7th. No. 590. D. PROUDFOOT: *Turkey Red Dyeing.*—This relates to a substitute for galls and sumac, which the inventor thought he had obtained in the *velani* tree or Turkish oak. *This patent was abandoned.*
- 1859—March 14. No. 643. T. LIGHTFOOT: *Fixing Colours on Woven Fabrics, etc.*—Relates to madder colours, which the patentee steams between the dyeing and soaping; and claims to have rendered the colour more resistant to soap, and the whites more easily cleared.
- 1859—March 19. No. 704. PICKSTONE & PICKSTONE.—*Stiffening, Sizing, and Weighting Textile Fabrics.*—The patentees claim the use of a peculiar clay found in Lancashire and other coal fields, covering the seams of coals, and called “black shale,” “crunch” or “cover.” It is reduced to a pulp and applied as china clay.
- 1859—March 21st. No. 710. R. WHITTAKER: *Manufacture of Rollers, Cylinders, and Mandrels for Printing.*—A plan for using thin copper shells. *This patent was abandoned.*

- 1859—March 26th. No. 770. SMITH & SMITH: *Preparation of a Colouring Matter for Dyeing and Printing*.—Claims the obtaining the colouring matter from commercial archil, in a solid form, by adding to it some acid or salt, which combines with the ammonia present. No advantages, as a colouring matter, are claimed; only an improvement in portability.
- 1859—March 26th. No. 771. BUCKLEY & OTHERS: *Printing Woven Fabrics*.—Mechanical appliances for printing with accuracy on both sides of the cloth.
- 1859—April 1st. No. 817. R. A. BROOMAN (Depouilly Frères, Paris): *Preparation of Indigo for Dyeing*.—The ground indigo is mixed with sulphite of lime and water added, to form a semi-liquid paste, and the whole is maintained for two hours at a temperature of from 140° to 160° F. *This patent was abandoned.*
- 1859—April 4th. No. 835. F. POTTS: *Rollers or Cylinders for Printing*. *This patent was abandoned.*
- 1859—April 8th. No. 880. N. A. GRUMEL: *Dyeing Cotton Wool, Silk, Flax, etc.*—Refers to making a black, without use of indigo; it consists in dipping the cotton in extract of logwood, drying, and then dipping in neutral chromate of potash or soda. Sulphate of copper is also to be used on occasions.
- 1859—April 12th. No. 921. R. A. BROOMAN (Renard Frères, Paris): *Preparation of Red Dyes*.—This is fuchsine, and is prepared by boiling a mixture of aniline and anhydrous bichloride of tin; the use of bichloride of mercury, perchloride of iron, and protochloride of copper is also claimed.
- 1859—April 12th. No. 922. S. LEEK: *Preparing and Treating Silk, and in Dyeing*.—The only novelty discernible here is in giving weight, strength, and elasticity to silk by soaking it in a mixture of gum and sugar.
- 1859—April 25th. No. 1,030. J. HIGGIN: *Treating Madder and similar Plants*.—In the making of garancine the patentee claims an advantage by leaving the acid and madder in contact for much longer periods than is usually the case; he claims the use of chloride of zinc and similar corrosive salts, to obtain a species of garancine from madder; and lastly, the preparation of an extract of madder from fresh roots, upon a principle derived from Schunck's researches upon madder, and which bears a certain relation to Verdeil and Michel's patent, March 5.
- 1859—April 27th. No. 1,060. J. HOLBOYD: *Finishing Wollen and other Cloths*.—Mechanical appliances to the perpetual cutting

machine, by which the nap of the cloth is cut to various depths at will, producing novel effects.

1859—April 30th. No. 1,090. C. H. G. WILLIAMS: *Manufacture and Application of Colouring Matters*.—The production of dyeing matters from the alkaloids quinine, cinchonine, strychnine, brucine, etc., by destructive distillation and oxidation; also, in treating aniline and analogous bodies with permanganate of potash, to obtain a purer purple colouring matter than is yielded by bichromate of potash.

1859—May 2nd. No. 1103. F. W. EMERSON: *A new Metallic Substance, and also Tungsten Products for Dyeing, Printing, etc.*—The patentee believes he has found a new metal, chlorlithenium, the compounds of which and some salts of tungsten he proposes to apply to dyeing in a very curious manner; and, if the author's experiments are worth anything, in a quite impossible manner also.

1859—May 7th. No. 1,155. R. D. KAY: *Preparation for Colouring Matters*.—A colouring matter called harmaline, made from sulphate of aniline, by treating it with peroxide of manganese, precipitating by ammonia, and dissolving out by alcohol.

1859—May 9th. No. 1,157. J. RAMSBOTTOM: *Machinery for Printing Fabrics*.—Mechanical appliances to enable rainbowed and eccentric patterns to be printed, and an improvement in the stretching bar.

1859—May 13th. No. 1,205. BEALE & KIRKHAM: *Colours for Dyeing and Printing*.—Refers to the treatment of aniline and its salts with chlorine and hypochlorites, by which the patentees state they are enabled to obtain not only purple or violet, but also drabs, greens, blues, and reds.

1859—May 14th. No. 1,209. W. E. GEDGE (Thénault, France): *Dyeing*.—Treatment of cotton for dyeing, by a mixture of soda crystals, sheep's dung, and oil; to be dyed in madder. *This patent was abandoned.*

1859—May 21st. No. 1,257. PERKIN & GRAY: *Mordanting and Dyeing Cotton, etc.*—Refers to the use of a lead mordant for aniline colours. The novelty appears to consist in the method of fixing the lead, which is printed as the acetate, and fixed in a bath containing carbonate of soda and caustic ammonia, and afterwards soaped. To prevent the dyes striking into the unmordanted parts they claim the use of soap and free fatty matters in the dye; the mordants are still able to attract the colour, while the whites are kept pure.

1859—May 23rd. No. 1,263. W. CRUM: *Printing and Dyeing*.—The patent consists in the application of alkaline solutions of gluten for

the purposes to which albumen has been usually applied. The gluten, obtained in the ordinary way, is either at once dissolved in alkali or submitted to a purification by being allowed to enter into incipient decomposition. It is used either as a mordant or a vehicle for pigments, but principally with the new aniline colours.

1859—May 23rd. No. 1,267. J. L. JULLION : *Dressing and Finishing*. Uses precipitated salts of lime, as a body ; preferring, however, sparingly, soluble salts. *This patent was abandoned.*

1859—May 25th. No. 1,288. D. S. PRICE : *Colours for Dyeing and Printing*.—Production of violet, purple, and rose colours, from aniline, by the use of sulphuric acid and the peroxide of lead, with subsequent purifying processes.

1859—May 28th. No. 1319. W. CRUM : *Printing and Dyeing*.—Refers to the use of gluten, which, when left for a certain time, becomes semifluid and requires no alkali (see previous patent of Crum's). Claims the application of lactarine and all caseine compounds, when applied as mordants ; but not as applied with the colouring matter, or after it. Mainly with reference to the aniline colours.

1859—June 2nd. No. 1,353. R. K. WHITEHEAD : *Apparatus for Bleaching, Dyeing, and Extracting, etc.*—Consists in forcing the liquids used in bleaching, etc. through the materials by atmospheric pressure, a vacuum being made in a connected vessel.

1859—June 6th. No. 1,381. T. HYLAND : *Gum or Dextrine*.—The use of the sour liquor resulting from the fermentation of flour as an acid converter of starch, etc.—*This patent was abandoned.*

1859—June 7th. No. 1,393. F. MUIR : *Colour Printing*.—An apparatus for printing several colours at once from a block. It does not appear to differ from the old "toby" apparatus.—*This patent was abandoned.*

1859—June 14th. No. 1,435. A. MC. DONALD : *Punching Patterns on Printing Rollers*.—A modification of the ordinary punching machine.

1859—June 24th. No. 1,522. FAURE & PERNOT : *Utilising Madder Residues*.—Evaporation of the water from garancine making and other treatments of madder, and using the product as a manure.

1859—July 2nd. No. 1,583. C. H. G. WILLIAMS : *Dyeing Fabrics and Yarns*.—This patent is for *not* purifying the crude colouring matter obtained by the action of bichromate of potash upon aniline ; and for the use of turpentine or caoutchene in purifying it.

1859—July 11th. No. 1,650. J. A. HARTMANN : *Manufacture of Colours for Printing*.—Refers to the topical application of madder

- colours made from lakes, with mixture of fatty substances and acids. *This patent was abandoned.*
- 1859—July 12th. No. 1,653. C. J. PROAL: *Photographic Impressions upon fabrics or tissues.*—Claims the application to photographic pictures, but gives no method of applying them.
- 1859—July 14th. No. 1,669. J. BAILEY: *Machinery for Stretching Woven Fabrics.*
- 1859—July 15th. No. 1,672. CLARK & WILLIAMS: *Finishing Woven Fabrics.*—Saturating the fabric made wholly or partly of wool with steam, previous to putting it through the finishing machine, by which better colours are obtained.
- 1859—July 20th. No. 1,704. CURTIS & HAIGH: *Finishing Cloths.*—Refers to an appliance for raising the nap in certain places only, thus producing a pattern or design.
- 1859—July 20th. No. 1,708. Z. G. A. N. P. ORIOLI: *Applications of Hypochlorite of Alumina to Bleaching and Dyeing, etc.*—The salt patented is made by mixing sulphate of alumina and bleaching powder; it is claimed as superior to bleaching powder, because it remains neutral during and after bleaching, leaving no acid to be removed by washing. It is applied as a mordant instead of acetate of alumina; and in a similar manner also as an antiseptic.
- 1859—July 25th. No. 1,729. G. DAVIES (communication from F. H. Hurstel, Paris): *Dyeing Yarns, Threads, Woven Fabrics, etc.*—For dyeing thread, etc., upon the bobbins, to supersede the winding and unwinding; it consists in the use of a vacuum, causing atmospheric pressure to force the mordant, or dye, in an equal manner, through the bobbin, or the pressure is obtained in other ways.
- 1859—July 27th. No. 1,743. T. DICKINS: *Dyeing and Discharging Warps, Woven Fabrics, etc.*—An appliance to produce a design upon warps, etc., by pinching certain parts between rigid pieces of wood, faced with india-rubber, which keeps the enclosed parts free from contact with the dyeing liquid. *This patent was abandoned.*
- 1859—July 27th. No. 1,744. JOHN SCOFFERN: *Waterproofing, Stiffening, Dyeing, etc.*—An attempted application of the ammoniuret of copper solvent of cellulose matters. The patentee states the solution of wool in this menstrua can be applied to cotton, and will act as a mordant.
- 1859—July 28th. No. 1,748. A. SIDEBOTTOM: *Separating Animal Fibre from Mixed Fabrics.*—Claims the method of treating mixed fabrics with mixtures of sulphuric acid and common salt, and sulphuric

acid and hydro-chloric acid; drying, heating, and beating out the cotton reduced to dust.

- 1859—August 5th. No. 1,808. R. T. PATTISON: *Dyeing certain Fabrics.* Consists in the use of alkaline solution of lactarine as a mordant for archil colours; the cloth to which the lactarine was applied being steamed. Same as Crum's patent. *This patent was abandoned.*
- 1859—August 8th. No. 1,830. G. T. BOUSFIELD: *Revivifying Scarlet Colour on Woollen Cloth.*—By the use of vegetable acids or acid salts. *This patent was abandoned.*
- 1859—August 13th. No. 1,878. C. MATHER: *Machinery for Stretching, Drying, and Finishing Fabrics.*
- 1859—August 29th. No. 1,962. J. R. HOWARTH: *Calendering and Finishing.*—*This patent was abandoned.*
- 1859—August 31st. No. 1,990. E. ELLIS: *Finishing Silk, made on Bobbin Net and Warp Frames.*—By winding the fabric lightly on a roller and steaming, the threads set, and bear wearing without displacement.
- 1859—September 3rd. No. 2,021. B. LAUTH: *Manufacture of Rollers or Cylinders for Calico Printers.*
- 1859—September 12th. No. 2,074. H. W. RIPLEY: *Finishing Dyed Piece Goods.*—Consists in passing goods which have been oiled, and which have not been well cleared from the dye liquor, through fuller's earth and water. *This patent was abandoned.*
- 1859—September 18th. No. 2,086. E. A. F. LEBOURGEOIS: *Machinery for Blockmaking.*—Improvements in fixing pins, wire, or stencil pins in blocks for surface printing.
- 1859—September 21st. No. 2,149. J. BLAIR: *Treatment of Yarns during the Spinning, Roving, etc.*—Appliances for bleaching, sizing, and dyeing the yarns, while undergoing the processes mentioned.
- 1859—September 21st. No. 2,154. DIMOCK & BAKER: *Drying Woollen and other Cloth.*—Machinery having an arrangement of fan blowers and pipes to drive or force hot air through the cloth while encasing the reels.
- 1859—September 26th. No. 2,176. R. KAY: *Preparing and Bleaching Textile Fabrics.*—Arrangements by which the bleaching agents are made to pass repeatedly through the material.
- 1859—September 29th. No. 2,207. C. DUPLOMB: *Presses for Finishing Textile Fabrics.*—The improvement consists in surrounding the press with steam chesting or hollow side pieces.
- 1859—October 18th. No. 2,332. HOLDEN & HOLDEN: *Washing, Dyeing, Sizing, etc.*—Refers to sizing and dyeing threads continu-

ously, by passing from one hobbin to another through proper baths.
This patent was abandoned.

- 1859—October 5th. No. 2,262. W. E. NEWTON (communication from S. W. Baker, United States): *Blanket for Printing Purposes*.—A composition of gutta percha, oxide of zinc, sulphur, and magnesia; which, being roughened near the edges, keeps the excess of colour from flowing back on the printed piece: and apparatus attached for washing the endless blanket or rubber.
- 1859—October 18th. No. 2,385. A. S. ROTT: *Substances for Fixing Colours in Dyeing and Printing*.—A method of preparing gluten by digesting it for some hours in very dilute acids, when it may be used as a substitute for albumen in aniline and similar colours.
- 1859—October 27th. No. 2,461. R. A. BROOMAN: *Red Colouring Matters*.—For making the fuchsine by bichloride of titanium and aniline, and several other metallic salts.
- 1859—October 27th. No. 2,473. LISTER & WARBURTON: *Dyeing Silk, Cotton, etc., and in Preparing and Spinning, etc.*—The novelty is in dyeing the material before being dressed or combed, so that two or more colours may be mixed in the spun thread.
- 1859—November 1st. No. 2,492. W. H. PERKIN: *Manufacture of Colouring Matter*.—Boiling aniline with bichloride of mercury to give a red colouring matter. *This patent was abandoned.*
- 1859—November 9th. No. 2,548. D. FULTON: *Cylinders or Rollers for Printing*.—With the intention of using a thin copper shell. *This patent was abandoned.*
- 1859—November 14th. No. 2,576. A. APPLGATH: *Block Printing*.—The block is mounted on an axis, or the block is fixed and the table mounted on an axis.
- 1859—November 15th. No. 2,594. T. D. PERKIN (from R. Knosp, Stuttgart): *Manufacture of Colouring Matter*.—By boiling aniline with anhydrous sub-nitrate of mercury, or other salts of mercury mentioned, by which a crystalline red colouring matter is produced.
- 1859—November 23rd. No. 2,650. W. KEATES: *Compound Cylinders used in Printing or Embossing*.
- 1859—November 26th. No. 2,675. F. SCHEITHAUER: *Machinery for Printing Woollen and other Fabrics*.
- 1859—November 28th. No. 2,694. R. A. BROOMAN (from Renard Frères, Paris): *Red Colouring Matters*.—By boiling aniline, and its analogues, with sulphate of tin, or a number of other salts, there is produced a red colouring matter several times patented.
- 1859—December 3rd. No. 2,746. C. L. SMITH (from A. Schlum-

berger, Mulhouse) : *Colouring Matter for Dyeing, etc.*—By boiling aniline with metallic nitrates, preferably nitrate of mercury, the red colouring matter, known as fuchsine, is produced.

- 1859—December 6th. No. 2,760. JONES & HILTON : *Apparatus used in Dyeing, Darning, Soaping, etc.*—This apparatus is a contrivance to get all the knotted ends of pieces together when it is necessary to untie them, thus saving time to the attendant. A slotted board, or similar appliance, is used, which detains the knots.
- 1859—December 7th. No. 2,777. R. T. PATTISON : *Printing and Dyeing Woven Fabrics and Yarns.*—The application of lactarine, dissolved in carbonate of soda, steamed, and then winced in milk of lime, as a mordant for certain colours. *This patent was abandoned.*
- 1859—December 10th. No. 2,800. R. HEILMAN (communicated by Gerber, of Mulhouse) : *New Colouring Matter called Azaëline.*—Obtained by boiling aniline with any one of an immense number of substances mentioned, without any preference being given. *This patent was abandoned.*
- 1859—December 10th. No. 2,801. CALVERT & LOWE : *Dyeing certain Yarns and Fabrics.*—For fixing aniline and archil colours. They use a mordant consisting of tannin matter and alumina as a substitute for albumen and lactarine. *This patent was abandoned.*
- 1859—December 14th. No. 2,845. W. WATSON : *Preparing Indigo for Dyeing.*—This refers to a sulphate of indigo from which the sulphuric acid is removed, by addition of carbonate or other salts of baryta.
- 1859—December 16th. No. 2,863. W. MOSLEY, Jun. : *Machinery for Washing, etc., of Textile Fabrics.*—Principally relates to the treatment of piece goods.
- 1859—December 17th. No. 2,870. J. SELLARS : *Size for Stiffening, Finishing, and Dressing.*—Consists in the use of solution of rosin in alkali, in combination with the usual matters. *This patent was abandoned.*
- 1859—December 23rd. No. 2,934. ARRIETA & LAMAR : *Bleaching, Cleansing, and Decolorising.*—Claims the steaming of the articles to be cleansed or bleached either with or without the contact of chemical substances. *This patent was abandoned.*
- 1859—December 24th. No. 2,939. E. HUBER : *Colouring Substances for Printing and Dyeing.*—By chemical treatments of naphthaline the patentee obtains products of various shades of red and purple. *This patent was abandoned.*

- 1859—December 28th. No. 2,963. W. A. GILBEE (communication from Charven, of Lyons) : *Green Colouring Matter, to replace Chinese Green.*—The colour is obtained by decoction of the fresh-cut bark of *Rhamnus Catharticus*; it is applied to silk by means of the acetate of alumina mordant.
- 1859—December 30th. No. 2,983. T. AUCHINCLOSS : *Machinery or Apparatus for Boiling and Washing Textile Fabrics.*

N.B.—The patentees, and not the author, are responsible for the assertions as to the efficacy of the processes patented which are contained in the above abstracts.

TECHNICAL TERMS AND SYNONYMES.

- Acetate*.—Combination of acetic acid with a base.
- Ageing*.—Exposure of printed or padded goods to the air for a few hours or days.
- Alterant*.—A chemical applied to fabrics after the colouring matter to develop or modify the shade.
- Aqua fortis*.—Nitric acid.
- Argols*.—Crude bitartrate of potash, impure cream of tartar.
- Ash*.—Commercial carbonates of soda or potash, sometimes also caustic alkali.
- Ashing*.—The act of treating goods with alkalis.
- Beck or Back*.—Vessel in which dyeing operations are performed.
- Black Liquor*.—Crude acetate of iron.
- Blue Copperas, Blue Stone*.—Sulphate of copper.
- Bowking or Bucking*.—The boiling of unbleached goods with lime or soda.
- Bowling*.—Washing of fabrics by passing over or between rollers.
- Branning*.—Boiling of dyed goods with bran and water.
- Chemic*.—Name frequently given to bleaching powder, and sometimes to sulphate of indigo.
- Chemicking*.—In bleaching, the application of the chloride of lime.
- Cleansing*.—The removal of thickening matters from printed goods before dyeing.
- Clearing*.—The removal of the colouring matter from parts stained in the dye, but intended to be colourless.
- Cloth*.—Any woven or felted fabric.
- Colour*.—Mordants prepared for printing, or colours proper.
- Croft*.—Any place where bleaching operations are conducted.
- Crystals of Soda*.—Crystallised carbonate of soda.
- Crystals of Tin*.—Crystallised proto-chloride of tin.

- Cutting*.—The process of modifying shades by acids or alterants.
- Dashing*.—Washing in a dash wheel.
- Delaine*.—Fabric made of cotton and wool.
- Dipping*.—Method of dyeing by simple suspension of the material in the dye bath, without the usual motion.
- Discharge*.—That which destroys or removes the colour or mordant.
- Double Muriate of Tin*.—Bi-chloride of tin.
- Dunging*.—The operation of passing printed goods through cow dung and water before dyeing.
- Entering*.—The first immersion of the material in the dye bath.
- Finishing*.—The preparation of the cloth for market after dyeing.
- Firing*.—Singeing ; removing the downy filaments from cotton cloth, by passing over a red hot plate.
- Fixing*.—Any process by which a mordant or colour becomes fixed to the fibre.
- Gassing*.—Singeing by means of jets of gas.
- Green Copperas*.—Green vitriol, protosulphate of iron.
- Hydrochloric Acid*.—Muriatic acid, spirits of salts.
- Iron Liquor*.—Crude acetate of iron.
- Killing*.—Neutralising of an acid by metals or alkalis.
- Lead Bottoms*.—Sulphate of lead.
- Lime Bottoms*.—Sulphate of lime.
- Liming*.—Boiling or bowking with lime and water.
- Nitrate*.—Compound of nitric acid and a base.
- Nitric Acid*.—Aquafortis.
- Padding*.—Covering the whole surface of cloth with a mordant or colour.
- Patent Alum*.—Sulphate of alumina.
- Pigment Colours*.—Insoluble colours applied by means of albumen, lactarine, etc.
- Piece Dyeing*.—Dyeing uniformly, without pattern or design.
- Pink Liquor*.—Aluminate of potash.
- Pink Salts*.—Double chloride of tin and ammonia.
- Plumb Spirits*.—Oxymuriate of tin.
- Prepared Rosin*.—Resinous soap.
- Preparing Salts*.—Stannate of soda and other compounds of tin.
- Raising*.—The fixing or developing of a colour.
- Red Liquor*.—Crude acetate of alumina.
- Red Spirits*.—Oxymuriate of tin.
- Resist*.—Preparation to prevent the fixing of a mordant or colour.
- Salt*.—In chemistry, any compound of an acid and base.

Salt of Tartar.—Carbonate of potash.

Salts.—Spirits of salts, hydrochloric acid

Sightening.—Adding something to make a mordant visible to the printer.

Skying.—Dyeing a light indigo blue by the roller vat.

Soaping.—Submitting dyed goods to the action of soap and water.

Sours.—Diluted sulphuric acid.

Souring.—Passage in diluted acids.

Spirits.—Acid solutions of tin, generally oxymuriate.

Spirit Colour.—A colour containing much oxymuriate of tin.

Steam Colour.—A colour to be fixed by steaming.

Stove.—A place for drying or ageing, not always heated.

Sugar of Lead.—Acetate of lead.

Sulphate.—A compound of sulphuric acid and a base.

Sulphate of Alumina.—Patent alum.

Sulphuric Acid.—Vitriol; oil of vitriol.

Sulphuring.—Exposure to sulphurous acid gas.

Tar Acid.—Wood acid; pyroligneous acid.

Tartar.—Cream of tartar; bitartrate of potash.

Tin Pulp.—Ferrieyanide of tin.

Thickening.—Gum, or similar substance giving viscosity to thin fluids.

Topical Colour.—A colour fixed without dyeing.

Vitriol.—Sulphuric acid.

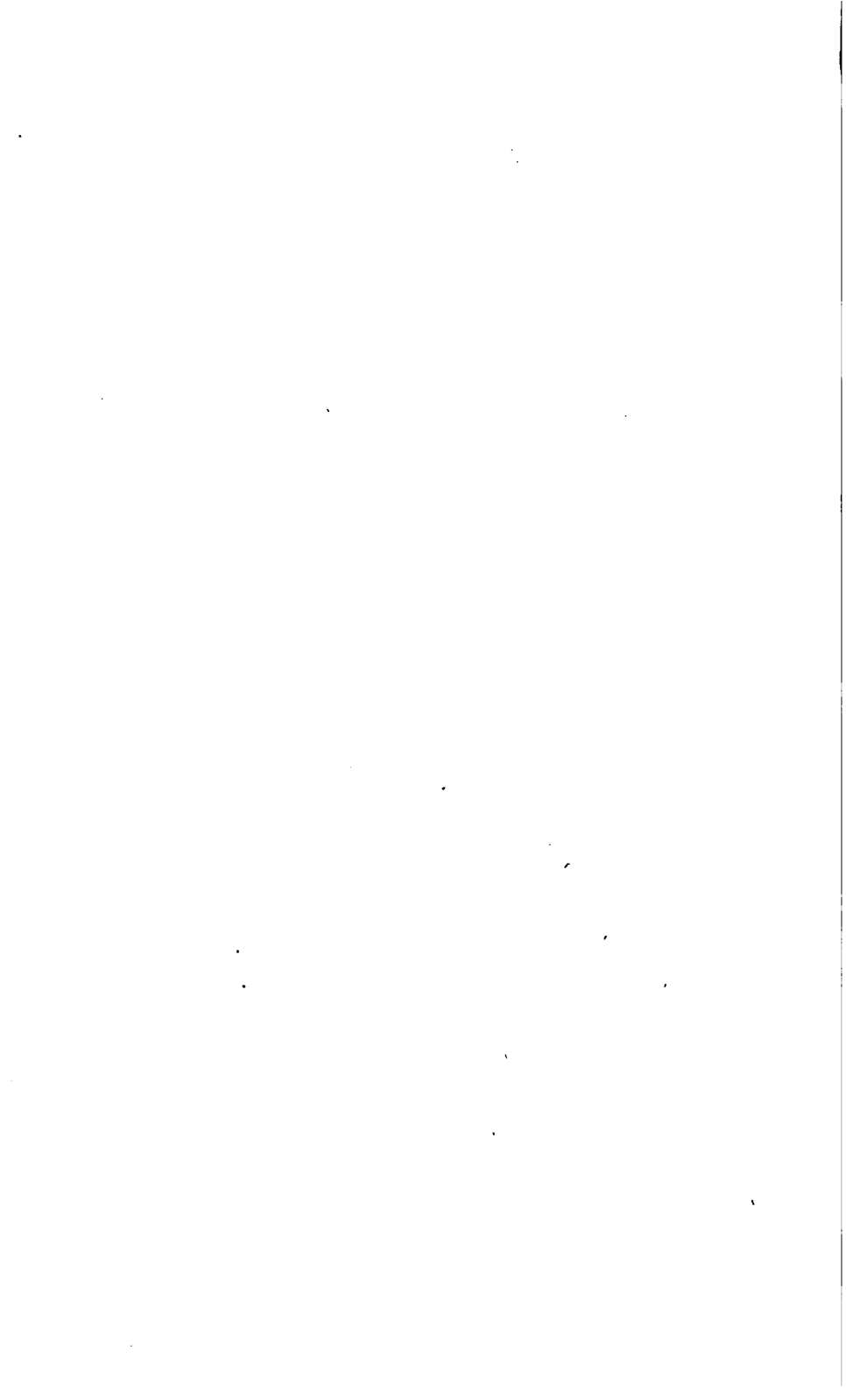
White Copperas.—Sulphate of zinc.

Wincing.—The action of passing fabrics through liquids by means of a wheel or wince.

Wood Acid.—Pyroligneous acid; tar acid.

Woods.—A dyewood proper; in contradistinction to madder, indigo, etc.

Yellow Spirits.—Oxymuriate of tin.



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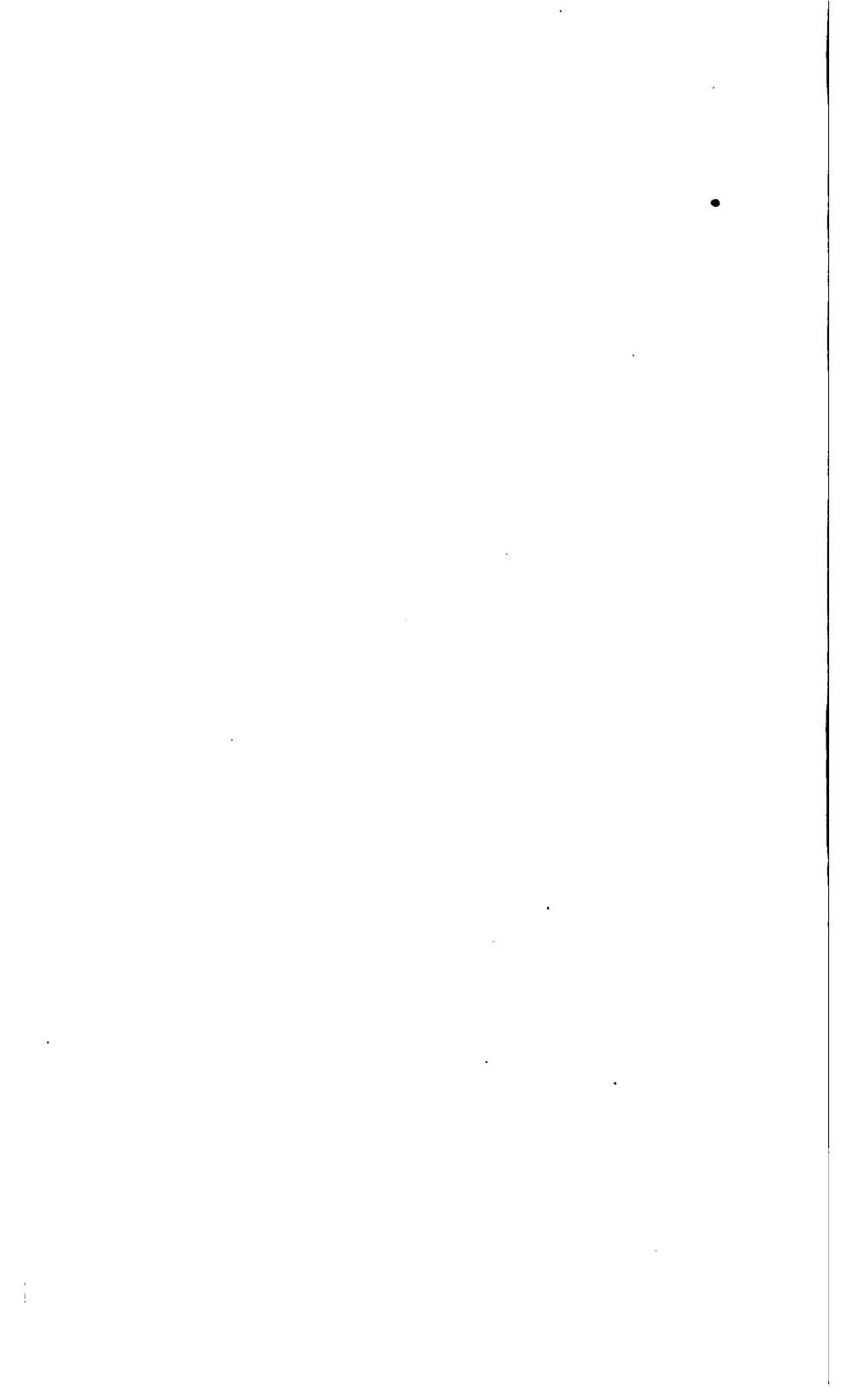
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